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The Santa Rita Experimental Range:

History and Annotated Bibliography (1903-1988)

**General Technical
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Abstract

The Santa Rita Experimental Range (SRER), founded in 1903, is the oldest research area maintained by the USDA Forest Service and has been a principal site for pioneer range research on the improvement and management of semiarid grasslands in the Southwest. The outdoor laboratory has provided a source for long-term ecological research. Results of this research have direct applicability to over 20 million acres of semiarid rangelands in the United States and to another 20 million acres in northern Mexico. The SRER is generally viewed as a world-class facility because of the long-term historical and biological data bases that have been maintained since its creation. The range has undergone major vegetational changes due to natural plant processes and management practices. The history of research, an environmental description, and a discussion on vegetational changes are provided along with a complete listing of scientific publications relating to SRER.

Keywords: Santa Rita Experimental Range, Arizona, semidesert grassland, bibliography, history

Acknowledgment

A debt of gratitude is expressed to all scientists who contributed to this effort. A special appreciation goes to Dr. S. Clark Martin who dedicated most of his professional career (55+ years) and retirement to conducting and organizing research, transferring technology to ranchers, resource managers and scientists, securing the integrity of historical data and photo records, and assisting graduate students with their research on Santa Rita Experiment Range (SRER). Another special thanks to Dr. David Griffiths, a pioneer in rangeland dynamics, whose work dating to the turn of the century provided the basis for the establishment of the SRER and whose photo collections provide an opportunity to view the past.

1908 photo from Santa Rita Experimental Range archives

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The Santa Rita Experimental Range: Annotated Bibliography (1903-1988)

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Introduction

The Santa Rita Experimental Range (SRER) was established in 1903 to protect the native rangeland from grazing and to conduct research on problems associated with livestock production. Accumulated information on ecology of the semidesert system at SRER is more complete than for any other tract of comparable size and diversity (Martin and Reynolds 1973[1]). The research results have worldwide applicability to other semidesert regions. Research conducted on SRER and other experimental ranges addressed the need to build a sound body of scientific knowledge to further the restoration, protection, and management of rangelands in the arid Southwest. SRER has also provided various socio-economic benefits to the local economy through research activities. Between 0.5 and 0.6 million animal unit months of forage have been realized since 1910.

This bibliography is a compilation of approximately 98 percent of all published research conducted on the Santa Rita Experimental Range between 1903-1988. The remaining 2 percent are those that are obscure in the voluminous publication outlets available for perusal or where the study area was not cited. The importance of the immense research cited is that much of our current knowledge of range and wildlife management of semidesert grassland ecosystems is derived from this work. Most of the research was perfomed entirely on SRER, with some investigations using SRER as a treatment site. Other works relate to SRER in that plant, soil, or animal products were taken from SRER for laboratory studies. This treatise contains over 450 references and works of over 225 authors. To assist the user in locating specific studies, several maps are provided in appendix D. For example, a large number of studies deal with mesquite and lehmann lovegrass experiments, which are on figure 19.

[1] *Please refer to the Annotated Bibliography for information on this publication and others in the history section.*

History of the Santa Rita Experimental Range

The Range

SRER consists of 53,159 acres about 35 miles south of Tucson in Pima County, Arizona (fig. 1) at the foot of the northwestern edge of the Santa Rita Mountains. It is characterized by small areas of steep, stony foothills and a few isolated buttes but the greater part consists of long, gently sloping alluvial fans. Upper fans slope rather steeply and are cut by canyons and arroyos. At lower elevations the slope diminishes to about 100 feet/mile and drainages become relatively shallow. Some parts of the lower range are characterized by terraces, breaks, or low escarpments and numerous gullies (Youngs and Poulson 1931). Elevations range from 2,900 feet in the northwestern corner to about 5,200 feet in the southeastern part. Average annual

Figure 1. Location of the Santa Rita Experimental Range.

rainfall increases with elevation, from 10 inches at 2,900 feet to almost 20 inches at 4,300 feet.

The soils are representative of those developed under southwestern arid conditions. Most consist of, or developed from, recent alluvial deposits. Three soil orders (Aridisols, Entisols, and Mollisols) and 21 soil series have been described by Clemmons and Wheeler (1970). The soils present an interesting range of characteristics due directly or indirectly to difference in elevation and proximity to the Santa Rita Mountains. With greater elevation and proximity to the mountains, rainfall increases, temperatures decrease, soils are darker, have a higher content of organic matter, and are more deeply leached of soluble salts. Erosion is most pronounced in the lower elevations coincident with vegetation density. Additional soil characteristics are provided in appendix A.

Major vegetation changes have occurred since the early 1900s. Velvet mesquite (*Prosopis juliflora var. velutina*) is the dominant overstory species on 20,000-30,000 acres where shrub-free grassland dominated 80 years ago. Mesquite and prickly pear cactus are major species above 4,000 feet, but other species including acacia (*Acacia greggii, A. angustissima),* mimosa *(Mimosa biuncifera, M. dysocarpa*), and false mesquite (*Calliandra eriophylla*) comprise 65 percent of the cover in this zone compared to 21 percent below 3,000 feet. Mesquite, burroweed (*Haplopappus tenuisectus*), and cholla cactus (*Opuntia fulgida, O. spinosior,* and *O. versicolor*) attain highest densities between 3,200 and 3,600 feet elevation (Martin and Reynolds 1973). Lower elevations (<3,200 feet) are dominated by creosote bush (*Larrea tridentata*).

Species composition of perennial grasses changes with elevation and rainfall (Martin and Reynolds 1973). Santa Rita threeawn (*Aristida glabrata*), Rothrock grama (*Bouteloua rothrockii*), and bush muhly (*Muhlenbergia porteri*) are important species of middle and lower elevations. Various species of gramas (*Bouteloua eriopoda, B. curtipendula, B. filiformis, B. chondrosioides, B. hirsuta*) are widely distributed at higher elevations. Arizona cottontop (*Trichachne californica*) and species of threeawns (*Aristida hamulosa, A. ternipes*) are common at all elevations. Lehmann lovegrass (*Eragrostis lehmanniana*) is presently the dominant grass over nearly 40 percent of the range.

Annual vegetation is most abundant in areas with light to moderate density of perennial grasses and where native grasses persist over lehmann lovegrass (Medina 1988). The prevalence of many dry washes and small gullies afford microhabitats where cool- and warm-season annuals can propagate. See appendix C for a complete list of plant species found on SRER.

A diverse fauna characteristic of the semidesert habitats is found on the SRER. Important game species include mule deer (*Odocoileus hemionus*), white-tailed deer (*O. virginianus*), collared peccary (*Tayassu tajacu*), Gambel's quail (*Lophortyx gambelii*), scaled quail (*Callipepla squamata*), mourning dove (*Zenaida macroura*), white-winged dove (*Zenaida asiatica*), and desert cottontail (*Sylvilagus auduboni*). Many other species of mammals, birds, and reptiles are common (see appendix B).

Hunting, nature studies, and bird watching are the principal recreational activities. Hunting has been largely restricted to small game, with occasional special-season big game hunts. Thousands of visitors travel through SRER each year enroute to Madera Canyon, a popular bird-watching area.

The geology varies from simple strata of recent deposits of alluvium to extensive thrust faulting. Alluvial caps cover about 95 percent of the area. These gravel strata vary in thickness from about 400 feet in higher elevations, to well over 2,000 feet in the lower parts. Small outcrops of granodiorite, limestone, sandstone, and other conglomerates constitute the remaining 5 percent.

Establishment

SRER was originally contained within the Santa Rita Forest Reserve, as established by Presidential Executive Order of April 11, 1902 by President Theodore Roosevelt. President Mckinley also signed an Executive Order on October 10, 1900, setting aside sections 26, 27, 34, and 35 in T.14S., R.14E, which were included in 1902 transfer. During this time, the forest reserves were administered by the Department of the Interior. In 1905, the forest reserves were transferred to the Department of Agriculture and consolidated with the Bureau of Forestry to form the Forest Service. In 1901, Dr. David Griffiths of the Bureau of Plant Industry and Dr. R. H. Forbes and Dr. J. J. Thornber, with the Agriculture Experiment Station at the University of Arizona in Tucson, began making observations and some investigations on SRER and at the Arizona Experiment Station (Griffiths 1904). In 1903, the Carnegie Institute of Washington established the Desert Laboratory at Tucson for continued work in studies of desert plants and range investigations.

On July 2, 1908, Executive Order 908 consolidated the Dragoon, Santa Catalina, and Santa Rita National Forests to establish the Coronado National Forest. On July 1, 1910, Executive Order 1222 transferred lands, then known as the Santa Rita Range Reserve, to the Bureau of Plant Industry, which was subsequently transferred to the Forest Service, Branch of Research, in 1915. Henceforth, SRER was administered as a Forest Service research area with no national forest system designation. On July 1, 1910, President Taft set aside 41,911.76 acres that consisted of most of the present size of SRER. Two other Executive Orders (4261 of July 3, 1925, and 4602 of March 2, 1927) added 12,120 acres. These latter Orders were revoked by Public Land Order No. 1363, November 15, 1956. But, an addition of about 711 acres, formerly described in the Secretary of

Agriculture's Regulation "U-4" of January 15, 1941, included the site occupied by the experimental range headquarters, resulting in the present size of 53,159 acres.

The Forest Service Southwestern Station's headquarters remained in Tucson until 1953, when it was consolidated with the Rocky Mountain Station. The Southwestern Station remained active until 1975, when the field unit was consolidated with the Experiment Station at Tempe.

Research Emphasis

Griffiths (1904) was essentially the first investigator with the Bureau of Plant Industry to initiate range investigations on SRER. Between 1900 and 1903, he made observations on (1) forage production, (2) plant phenology, (3) plant inventories, (4) carrying capacity, (5) erosion, (6) livestock behavior, and (7) range conditions. The Bureau's research objectives were to determine the period of time that would be necessary for the range to regain its productivity, and to determine the grazing capacity of such a range once it had reached a satisfactory condition. The Bureau's research objectives from 1900-1915 were basic studies of the growth habits of important forage plants and grasses to determine the best methods of assessment, care, and improvement of grazing lands.

At the time of the establishment of the SRER in 1903, forage conditions had deteriorated due to unregulated heavy yearlong grazing the previous years. The area was immediately fenced and domestic livestock were excluded until 1915. In 1915, responsibility for range research outside the National forests was transferred to the Forest Service. This resulted in additional intensive studies of the relation of climate to range-plant growth and use, and methods of range management on semidesert ranges.

Range research ceased during World War I but quickly resumed after the war. The passage of the McSweeney-McNary Forest Research Act of 1928 marked a new epoch in range research. All Forest Service range research was consolidated under regional forest and range experiment stations, with integration and coordination of range research on a national basis with other research agencies.

Emphasis of range research on SRER changed over time. SRER was not grazed between 1903-1915; hence, investigations before 1915 dealt primarily with assessment of range conditions and determination of possible strategies for betterment of rangeland resources. Grazing on SRER was initiated in 1915 and continued to 1957 on a yearlong basis. Between 1915 and 1940, investigations focused on range economics, betterment of livestock breeds and calf crops, and livestock management strategies, but were driven by two major objectives. First, was determination of better methods for managing semidesert range lands, typical of Santa Rita, for the purpose of improving and maintaining them on a sustainable basis of productivity. The second objective focused on handling cattle on the range to obtain the greatest annual returns. Some important wildlife reasearch dealt with the impacts of rodents on the range resources and determination of foods of mule and white-tailed deer. Other studies started during this period continued until the 1960s and 1970s (e.g., noxious plant control, determination of grazing capacity, season of use, and proper use levels of semidesert grasses). Grazing systems research began as early as 1937 with tests of yearlong grazing versus summer deferment.

A program of evaluating range reseeding trials began in 1935 and ended in the mid-1950s. During the 1940s, as a result of the Hope-Flannagan Research and Marketing Act, funds became available for basic research on the physiology and ecology of noxious range plants. Several studies were started: relationships (reproduction, production, and survival) of important semidesert plants; cattle grazing habits; resistance of forage grasses to grazing; and vegetational changes over time. Great attention was paid to undesirable species such as burroweed, cholla cacti, mesquite, and prickly pear, and methods of control.

The 1950s and 1960s, coincident with the consolidation of the Southwestern Station with the Rocky Mountain Station in 1953, were a time of basic research on semidesert grasses. Various studies dealing with plant competition relationships, plant-drought interactions, and physiological response of mesquite to herbicides were initiated. Major emphasis was placed on control of mesquite, burroweed, and other undesirable species. These same efforts led to the study of the effects of fire (mortality, production, resistance) on various grasses and shrubs. Coincident with these studies, the ecology and life history of grass and noxious plants were also studied. Some basic studies dealing with deer-livestock interactions were initiated. The successful establishment of lehmann lovegrass in 1954 led to various works dealing with the use and management of the species up until the closure of the Southwestern Experiment Station in 1975.

Since 1975, research on semidesert grasslands has been de-emphasized in light of other problems, such as wildlife-livestock interactions, production and utilization of Lehmann's lovegrass, cattle foraging behavior, and small mammal habitat interactions. Extensive research has been conducted on rodent habitats, insects, quail, javelina, coyotes, and deer. The establishment of Lehmann's lovegrass as a monoculture presented new challenges to develop strategies for its proper utilization. However, the extensive amount of work performed on SRER led to the present state of knowledge or range management principles on semidesert grasslands, especially grazing systems, seasons of use, production-utilization levels, and general range ecology. Resource managers draw upon this data base to design management plans and grazing strategies suitable for Southwestern rangelands.

Vegetational Changes (1903-1988)

Dramatic changes in the type and amount of vegetation have occurred since the early 1900s. Examples of these changes since 1902 are in figures 2-16. In 1902 (fig. 2), draws were characterized by young stands of velvet mesquite, which matured and retained a woody aspect over time (figs. 3,4). However, uplands were generally devoid of woody plants (figs. 5,8) and characterized more by a grassland aspect. Burroweed was the dominant woody plant on uplands. Density of burroweed was documented to peak around 1908, 1935, 1959, and 1969, with each peak following one or more exceptionally wet winter-spring periods and with low densities following severe winter drought (Martin 1986a). Jumping cholla cactus was absent on uplands in 1903, 1905, 1922 (figs. 8, 5, and 11) but locally abundant in the 1940s and 1950s (figs. 6, 9, and 12), and declined to low densities in the 1980s (figs. 7, 10, and 13). Martin (1986a) reported the population cycle to be about 40 years. Velvet mesquite increased dramatically on more mesic uplands (figs. 5-13) but some sites (rocky, clayey types) retained their grassland aspect (figs. 14-16). Some grassland sites retained their aspect and native vegetation (figs. 5-7), but sites where lehmann lovegrass was seeded and/or subsequently spread to other sites changed aspect to either a mesquite-lehmann lovegrass savannah or pure stands of lehmann lovegrass (figs. 8-16). Lehmann lovegrass has replaced many of the native herbaceous species on vast areas that once were native grasslands.

Current Status

SRER continues to function as an outdoor laboratory, providing study areas for various research cooperators. Research planning and administration is coordinated via the Santa Rita Research Committee, a committee of research cooperators comprising five members. The committee includes two members from the University of Arizona; one from the USDA Science and Education Administration; one from the Coronado National Forest; and one from the USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. Final responsibility rests with the latter agency. Current investigations cover lehmann lovegrass productivity, grazing systems, and various wildlife studies, performed primarily by cooperators.

SRER is available to scientists for conducting research. If interested, contact the Department of Renewable Natural Resources, University of Arizona. Also, most of the references in the Annotated Bibliography are in the University of Arizona Library, Special Collections (Santa Rita Experimental Range), especially those with no dates. Included in this library are copies of administrative reports dating back to early 1900s. These administrative reports contain valuable insight into the then current conditions of range and forests of various forests in the Western United States. Many accounts depict the problems that resource managers were faced with at the time. Nearly every forest in the Southwest is described in terms of problems related to grazing, tree production, and watershed condition. Also included in this library are original records of research data, hand written notes from respective scientists and maps showing location of the study plots on SRER. This type of information is invaluable for conducting long-term evaluations of flora and fauna of the semi-desert grassland of the Southwest.

Literature Cited

Clemmons, Stan; Wheeler, L.D. 1970. Soils report: Santa Rita Experimental Range, Coronado National Forest. Albuquerque, NM: U.S. Department of Agriculture, Forest Service, Southwestern Region. 41 p.

Griffiths, David. 1904. Range investigations in Arizona. Bureau of Plant Industry Bulletin No. 67 (10 plates). Washington, DC: U.S. Department of Agriculture. 62 p.

Martin, S. C. 1986. Eighty years of vegetation change on a semidesert range in southern Arizona, U.S.A. and evaluation of causes. *In:* Rangelands: A resource under siege. Proceedings of Second International Rangeland Congress; Ross, P. J.; Lynch, P. W.; Williams, O. B., eds.; 1986; Canberra, Australia. Sydney, Australia: Cambridge University Press: 53 p.

Martin, S. Clark; Reynolds, Hudson G. 1973. The Santa Rita Experimental Range: Your facility for research on semidesert ecosystems. Journal of the Arizona Academy of Science. 8: 56-67.

Medina, Alvin L. 1988. Diets of scaled quail in southern Arizona. Journal of Wildlife Management. 52(4): 753-757.

Youngs, F. O.; Poulson, E. N. 1931. Soil survey of the Santa Rita Experimental Range, Arizona. Washington,

1902

1941

1988

Figures 2, 3, 4. Photo sequence showing relative changes in density of mesquite between 1902, 1941, and 1988, looking east up Proctor Canyon. Mesquite density changed little on wooded draws compared to upland sites.

1905

1941

1988

Figures 5, 6, 7. Photo sequence showing differences in range conditions and vegetational changes from grassland (1905) to a more woody type dominated by cactus (1941) to a mesquite savannah (1988). Vegetation species are native grassland species.

1903

1951

1988

Figures 8, 9, 10. Photo sequence showing differences in range conditions between 1903, 1951, and 1988. In 1903 and 1951, native vegetation was the dominant aspect, whereas in 1988 the understory had become largely a monoculture of lehmann lovegrass, an exotic. Note also the change in woody composition similar to figures 5-7.

1922

1947

1986

Figures 11, 12, 13. This upland site changed from a native grassland site (1922) with few woody species to a mesquite-cactus-burroweed type (1947) to a mesquite-Lehmann lovegrass-dominated savannah (1986). Note that cactus has completely cycled through and lehmann lovegrass has outcompeted burroweed.

1936

1959

1988

Figures 14, 15, 16. Photo sequence showing little encroachment by woody plants between 1936, 1959, and 1988. Range condition improved significantlly, with native species still dominant in 1959. Pastures of this type are presently classified as monocultures of lehmann lovegrass.

Annotated Bibliography

1. **Al-Mashhdany, Showket Abdalah. 1978. Chemical control of the annual weeds of southern Arizona rangeland. Tucson, AZ: University of Arizona. 55 p. M.S. thesis.**

Pre-emergence winter applications of herbicides were unsatisfactory. Dicamba (2 kg/ha) was most effective and removed 88% of dormant winter weeds. Post-emergence application of glyphosate and picloram were most effective. Most summer treatments allowed good to excellent control of both broadleaf and grassy weeds. Atrazine and dicamba (2 kg/ha) gave 97-100% control. Tebuthiuron (1 kg/ha) removed all of the annual summer weeds. Post-emergence summer treatments showed that dicamba, MSMA, and picloram removed all weeds.

2. **Alonso, Ramon Claveran. 1967. Desert grassland mesquite and fire. Tucson, AZ: University of Arizona, Department of Watershed Management. 182 p. Ph.D. dissertation.**

Blue grama plants burned in the field using four fuel levels decreased in dry weight production by about one-half, regardless of the amount of fuel. Crude protein content was higher on the burned plants. No plants were killed by the fire. The dry weight produced by blue grama and sideoats grama two months after laboratory-burn treatments was inversely related to the temperature and length of time. Mesquite damage by fire was variable with respect to fuel loads. Oak bark was a better insulator than that of mesquite. Heat resistance in young mesquites appeared to be a function of age.

3. **Anderson, Anders H.; Anderson, Anne. 1959. Life history of the cactus wren. Part II: The beginning of nesting. Condor. 61(3): 186-205.**

The cactus wren's territory is used for mating, nesting, and as a feeding ground for the young. It is also retained as a roosting area for the remainder of the year. Autumn roosting nests seldom remained intact until the next year's breeding nest was begun. Average time from beginning of construction to the laying of the first egg was about 14 days. Variation in time of the laying of the first egg was great.

4. **Anderson, Darwin; Hamilton, Louis P.; Reynolds, Hudson G.; Humphrey, Robert R. 1953. Reseeding desert grassland ranges in southern Arizona. Bulletin 249. Tucson, AZ: University of Arizona, Agricultural Experiment Station. 31 p.**

Revised 1957, refer to Anderson et al. 1957.

5. **Anderson, Darwin; Hamilton, Louis P.; Reynolds, Hudson G.;Humphrey, Robert R. 1957. Reseeding desert grassland ranges in southern Arizona. Bulletin 249. Tucson, AZ: University of Arizona, Agricultural Experiment Station. [Originally issued 1937 by Agriculture Experiment Station, Reseeding desert grassland ranges in southern Arizona.] 31 p.**

Several factors, (site quality, rainfall, etc.) considered in reseeding, including methodology, are discussed in detail with species recommendations for various desert grassland sites.

6. **Arizona Game and Fish Department. 1976. Hematology of deer. Final report: Federal Aid in Wildlife Restoration Project W-78-R, Work Plan 3, Job 4. 9 p. Phoenix.**

Serology tests for 6 diseases were run on blood samples from a total of 183 mule deer and white-tailed deer from several areas. Of these, 10% had a significant test for BTV, 17% were positive for PI-3, 30% were positive for IBR, and 16% were positive for BVD. Only a single whitetail sample was positive for Leptospirosis and none for Brucellosis. Values for 18 blood chemistry components are listed for 35 mule deer samples from three areas. White-tailed deer values are pooled for all areas from which they came.

7. **Arnold, J. F. 1946. Plot studies on the effects of nitrates on a southwestern range. Tucson, AZ: University of Arizona. 66 p. M.S. thesis.**

Plant samples from fertilized plots had higher cell-sap concentrations than check plots. Fertilizer increased the number of individual plants, except where more luxuriant growth resulted in competition. Fertilized plants showed increases in the number and length of leaves. An increase in density of plant cover, palatability, harvested dry weights, and seed production was noted on all fertilized plots.

8. **Arnold, Joseph F. 1942. Forage consumption and preferences of experimentally fed Arizona and antelope jackrabbits. Technical Bulletin 98. Tucson, AZ: University of Arizona, Agricultural Experiment Station. 86 p.**

The average daily forage consumption (absolute values) of Arizona jackrabbits ranged from 5.6% to 6.7% of body weight and 5.8% to 6.5% of body weight for antelope jackrabbits. Palatability tests were made on 32 grass species, 47 weed species, and 21 species of browse. Jackrabbits appeared to prefer plants in order of weeds, grasses and browse with the first two making up the major and about equal parts of the diet. It is suggested that once range deterioration is well under way, jackrabbits may be a partial cause of overgrazing, and in the final stages of deterioration may be the primary cause of depletion. When competition is considered to be direct, 62 ± 7 Arizona jackrabbits and 48 ± 2 antelope jackrabbits consume the equivalent of one 1,000-pound range cow.

9. **Arnold, Joseph F.; Reynolds, Hudson G. 1943. Droppings of Arizona and antelope jackrabbits and the "pellet census." Journal of Wildlife Management. 7(3): 322-327.**

Arizona and antelope jackrabbits fed in captivity on different types of food show certain characteristic depositions of fecal material. The age and weight of mature animals do not affect the number or weight of pellets voided by either species of jackrabbit.Pellet count remains constant, on the average, regardless of age, sex, size or species of rabbit. A jackrabbit of either species voids an average of 531 ± 27 pellets per day when eating green, native forage material. Pellet weight and weight of food consumed show a direct linear relationship. When eating green native forage the animals of either species void about 55% of the weight of ration ingested. Character of forage consumed has a greater effect upon pellet weights than upon pellet counts. Some uses of pellet weights and counts are outlined. The use of pellet weights to determine forage removal is suggested.

10. Barr, George V. 1955. A comparison of the survival over a twenty-year period of several native Arizona grasses. Tucson, AZ: University of Arizona. 34 p. M.S. thesis.

This study assessed the relative survivability of 12 native grasses transplanted between 1935 and 1937. Results indicated that under total protection (from cattle and rodents), *Bouteloua eriopoda, Trichachne californica, Boutelouz curtipendula, Boutelouz chrondrosioides, Aristida divaricata, Heteropogon contortus,* and *Muhlenbergia porteri* exhibited greater survival rates in decreasing order. Under cattle protection only, *Boutelouz curtipendula* appeared most successful. Four other species failed to appear in their subplots.

11. Barth, Richard Charles. 1975. Spatial distribution of carbon and nitrogen in some desert shrub ecosystems. Tucson, AZ: School of Renewable Natural Resources, University of Arizona. 143 p. Ph.D. dissertation.

Over 77% of ecosystem nitrogen was contained in the soil, 20% in shrub phytomass, and 3% in understory phytomass and litter. Carbon was almost equally distributed between soil and phytomass. Total ecosystem phytomass for mesquite and palo verde were similar and averaged 5.8 kg/m². Soil nitrogen and carbon decreased with distance from shrub centers. Seasonal and annual changes in nitrogen and carbon were found for many components of two ecosystems.

12. Bashford, Leonard Leroy. 1966. An automatic animal weight recording system. Tucson, AZ: School of Renewable Natural Resources, University of Arizona. 46 p. M.S. thesis.

A scale platform was suspended from a supporting structure by four strain gage load rings. Weight supported by the load rings triggers an electrical signal that is recorded by an oscillograph. Signal magnitude is correlated with animal weight through calibration of the system. Field tests proved the method adequate and reliable.

13. Beal, Raymond H.; Carter, Fairie Lyn. 1968. Initial soil penetration by insecticide emulsions used for subterranean termite control. Journal of Economic Entomology. 61(2): 380-383.

Chlorinated hydrocarbon insecticide emulsions penetrated least in arid soils from Arizona and Oregon and most in soils from Missouri in a test of seven soils from various parts of the United States. Soil moisture at application time appeared to enhance penetration. After 24 hours in most tests, more than half of the insecticide applied was found in the upper 3/4 inch of soil. The parts per million of insecticide measured in 6 layers of soils did not differ appreciably in samples taken 1, 4, and 24 hours after application. Chlordane, dieldrin, and heptachlor were the insecticides tested.

14. Bentley, R. Gordon, Jr. 1964. The effects of three moisture levels applied to lehmann lovegrass grown on a fertilized desert grassland soil. Tucson, AZ: University of Arizona. 35 p. M.S. thesis.

Results showed that on fertilized soil, significant increases in herbage production, number of stems per plant, and crude protein content were obtained for all levels of water. Soils not fertilized showed no gain above normal levels. Soil nitrate was decreased at the normal and above normal water levels on fertilized soils.

15. Blair, Byron O. 1950. Recent results of basic physiological studies of mesquite in the Southwest. Western Weed Control Conference Proceedings. 12:104.

A short report on research being conducted on absorption, movement, and toxicity of organic and inorganic herbicides applied to mesquite.

16. Blair, Byron O. 1951. Mesquite seed and seedlings response to 2,4-D and 2,4,5-T. Botanical Gazette. 112(4): 518-521.

This paper reports on studies of germinating seeds and young seedlings of mesquite. Seeds and seedlings were found to be responsive to 2,4-D and 2,4,5-T but not as sensitive as other desert woody plants. Concentrations above 1 ppm of 2,4,5-T were more toxic than 2,4-D. Applications of higher concentrations (>1 ppm) to mature plants as foliar sprays have not resulted in kills, indicating either lack of absorption and translocation or greater resistance of mature plants.

17. Blair, Byron O.; Fuller, W.H. 1952. Translocation of 2,4-dichloro-5-lodo-phenoxyacetic acid in velvet mesquite seedlings. Botanical Gazette. 113(3): 368-372.

This paper reports on techniques used and quantitative data obtained on translocation of 2,4-DI, with and without added adjuvants, applied as herbicidal concentrations in spray form to foliage of velvet mesquite seedlings. A simple technique by which seedlings tops were isolated for spray-

ing is described. Results showed that 96 hours after spraying, less than 3% of the deposited radioactive material had moved from the tops to tissue located more basally.

18. Blair, Byron O.; Glendening, George E. 1953. Intake and movement of herbicides injected into mesquite. Botanical Gazette. 115(2): 173-179.

Several herbicidal solutions injected into mesquite stems in the absence of air show that time of year was the most important factor affecting the amount of solution intake. Lateral movement of herbicides was negligible and downward movement was limited.

19. Blake, Steven Bruce. 1980. Prediction of forage yield from simulated soil moisture deficits. Tucson, AZ: University of Arizona. 167 p. M.S. thesis.

The sensitivity of the model to the method used for the calculation of potential evapotranspiration (PET), actual evapotranspiration (AET), and soil moisture movement was evaluated using actual data. The PET method has a negligible effect, but the AET method selected was important to soil moisture estimation, with the more complex methods giving the most accurate results. The model explained 85% (R=0.92) of the variation in observed values over the period of calibration and 64% (r=0.80) over the period of validation.

20. Blydenstein, John. 1966. Root systems of four desert grassland species on grazed and protected sites. Journal of Range Management. 19(2): 93-95.

Root systems of species of Aristida, Bouteloua and Trichachne were restricted to the upper 7 inches of soil, with depth penetration of roots influenced by characteristics of the soil. Grazing affected root development by reducing the amount of branching of first-order roots and, in two species of Bouteloua, by decreasing total root density. Root diameter was not affected.

21. Bohning, John W. 1956. What will burning do for your semidesert range? Arizona Stockman. 22(11): 14-15.

Burning before summer rains will kill most of the burroweed and make deep inroads into cholla, prickly pear, and barrel cactus. Burning temporarily increased soil fertility by releasing small amounts of nitrogen and soluble minerals. Overall grass density was reduced one-third, but the loss was regained by the end of three growing seasons.

22. Bohning, John W. 1958a. Salting for better livestock distribution. Arizona Cattlelog. 13(5): 60-61.

Contrary to popular opinion, cattle do not go directly from salt to water but may graze several hours between salting and watering if salt and water are some distance apart. Salt, or meal-salt mixture, placed on lightly grazed areas, aids in obtaining more uniform utilization. Best results in the Southwest can be obtained during the cool months of the year when cattle water less frequently.

23. Bohning, John W. 1958b. Who can afford to haul water? The American Hereford Journal. 49(5): 656-657.

The benefits derived from hauling water to livestock on the range include (1) reduced feed bills, (2) reduced grazing pressure around permanent watering places, (3) better utilization of remote parts of the range, and (4) better control and care of the livestock.

24. Bohning, John W.; Martin, S. Clark. 1956. One rancher's experience--in the grassland range of southern Arizona. Journal of Range Management. 9: 258-260.

A description of range management practices on a well-managed range livestock operation in southern Arizona. Good range management and good animal husbandry practices are the essentials of this rancher's successful operation.

25. Brown, Albert L. 1950. Shrub invasion of southern Arizona desert grassland. Journal of Range Management. 3(2): 172-177.

Changes in numbers of burroweed and mesquite were directly correlated with grazing pressure. Total protection was insufficient to decrease the numbers of burroweed materially and failed to retard the increase of mesquite sufficiently to appear as a usable control method. Increases of other shrubs showed little relationship to protection.

26. Cable, Dwight R. 1959. Some effects of fire and drought on semidesert grasses and shrubs. Tucson, AZ: University of Arizona. 27 p. M.S. thesis.

Burning produced its greatest effect in the growing season immediately following burning. Burroweed was effectively killed by burning in June and responded to climactic changes by increasing in numbers during periods of above-average winter precipitation. Fire and drought had inconsistent effects on mesquite and cactus. Most perennial grasses lost basal area during the growing season immediately following the first burn. Drought appeared to exert a greater negative influence on perennial grasses.

27. Cable, Dwight R. 1961. Small velvet mesquite seedlings survive burning. Journal of Range Management. 14(3): 160-161.

One-third of velvet mesquite seedlings burned when 8 and 12 months old were top-killed only and sprouted later from the base; the other two-thirds were completely killed. Age of seedlings had no effect on the results.

28. Cable, Dwight R. 1965. Damage to mesquite, Lehmann lovegrass, and black grama by a hot June fire. Journal of Range Management. 18(6): 326-329.

Twenty-five percent of mesquite trees were killed on an area with lehmann lovegrass ground cover compared to

8% on an area with black grama. Ninety percent of black grama plants and more than 98% of lovegrass plants were killed. Many new lovegrass seedlings became established on both areas.

29. **Cable, Dwight R. 1966. Competition between burroweed and annual and perennial grasses for soil moisture. *In:* Proceedings of American Forage and Grassland Council; 1966 February 1-4; New Orleans, LA: 11-27.**

Because burroweed has a taproot and is primarily a spring grower, summer yields of annual and perennial grasses were only moderately affected by burroweed. Perennial grasses competed strongly with annual grasses and burroweed during the summer growing season.

30. **Cable, Dwight R. 1967. Fire effects on semidesert grasses and shrubs. Journal of Range Management. 20(3): 170-176.**

Immediate effects of fire on perennial grasses lasted only 1 or 2 years. Burroweed was easily killed but came back quickly with adequate cool-season moisture. Fire was relatively ineffective against mesquite and fairly effective against cactus.

31. **Cable, Dwight R. 1969a. Competition in the semidesert grass-shrub type as influenced by root systems, growth habits, and soil moisture extraction. Ecology. 50(1): 27-38.**

Measurements of phenological development, herbage production, basal area, and density of annual and perennial grasses and of burroweed over a 4-year period show that production of each class of plant was affected to some extent by each of the others, except that annual grasses had no effect on burroweed crown area. Production of Arizona cottontop, the dominant perennial grass, was restricted about 25% on plots with annual grass or burroweed competition and 46% by both together. Annual grass production averaged 18% lower with burroweed competition and 44-54% lower with perennial grass competition. Burroweed crown area increased 220% on plots with no perennial grass but only 111% on plots with perennial grass competition. Presence of burroweed reduced perennial grass yield only moderately because the root systems of burroweed and grass do not overlap greatly, and their main growth periods are at different seasons. High evaporation rates during the summer growing season masked most differences in moisture extraction between species. During the winter-spring growing period, on the other hand, burroweed depleted the available soil water rapidly, while water loss on perennial grass plots was little more than from bare soil.

32. **Cable, Dwight R. 1969b. Soil temperature variations on a semidesert habitat in southern Arizona. Research Note RM-128. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 4 p.**

Daily minimum soil temperatures were lowest at the surface and increased with depth; daily maximum soil temperatures were highest at the surface and decreased with depth. Diurnal variation was greatest (as much as 75° F) at the surface and lowest (1° or 2° F) at the 24-inch depth. Soil temperatures at the 3-, 12-, and 24-inch depths ranged mostly between 40° and 60° F during the winter months and between 70° and 90° F during the summer months. Absolute maximum and minimum temperatures recorded were 141° and 29° F.

33. **Cable, Dwight R. 1971a. Growth and development of Arizona cottontop (*Trichachne californica* [Benth] Chase). Botanical Gazette. 132(2): 119-145.**

This comprehensive study discusses in great detail the phenological development of Arizona cottontop. Special attention is given to time-growth and moisture-growth related functions.

34. **Cable, Dwight R. 1971b. Lehmann lovegrass on the Santa Rita Experimental Range, 1937-1968. Journal of Range Management. 24(1): 17-21.**

In a 10-year study, perennial grasses increased in response to favorable rainfall and mesquite control and did better on fine than on coarse textured soils. Because of heavy spring use, grazing November to April was less favorable for perennial grasses than May to October or yearlong grazing.

35. **Cable, Dwight R. 1972a. Fire effects in southwestern semidesert grass-shrub communities. *In:* Proceedings Annual Tall Timbers Fire Ecology Conference; 1972 June 8-9; 109-127.**

Shrubs are most susceptible to burning in June. Opportunities for planned burning are limited in areas of insufficient herbaceous ground fuels. Some perennial grasses (lehmann lovegrass, Santa Rita threeawn) survive burning very well, others survive intermediately well (Arizona cottontop, Rothrock grama, tanglehead), and others are easily damaged (black grama, tall threeawns).

36. **Cable, Dwight R. 1972b. Fourwing saltbush revegetation trials in southern Arizona. Journal of Range Management. 25(2): 150-153.**

Fourwing saltbush was seeded and transplanted into native stands of (a) almost pure creosotebush and (b) velvet mesquite with burroweed understory, in southern Arizona. Burroweed and creosotebush were controlled by picloram spray and by grubbing. The mesquite was killed on half of the burroweed plots. Establishment and survival of saltbush was much higher on the creosotebush site than on the mesquite site, presumably because calcareous (pH 8.0+) soil at the creosotebush site was more suitable than the noncalcareous neutral soil at the mesquite site. Transplants survived better on grubbed plots than on sprayed or check plots. Seedlings survived better on sprayed or grubbed plots than on check plots. However, after 3 years stands were reduced to 650 and 46 plants per acre on the creosotebush and mesquite-burroweed area respectively.

37. Cable, Dwight R. 1972c. Seasonal use of soil moisture by mature velvet mesquite (*Prosopis juliflora* var. *velutina*). US/IBP Desert Biome Research Memorandum 72-18. Logan, UT: Ecology Center, Utah State University. 4 p.

Soil moisture measurements were taken with a neutron probe on 30 dates between July 10 and December 31, 1971, to determine the pattern of soil moisture use by 4 mature velvet mesquite trees (*Prosopis juliflora* var. *velutina*) both in time and within a soil mass 6 m deep and extending laterally 20 m from the tree trunk. Data were submitted to the Biome data bank, but no summaries were prepared.

38. Cable, Dwight R. 1974. Seasonal use of soil moisture by mature velvet mesquite (*Prosopis juliflora* var. *velutina*). US/IBP Desert Biome Research Memorandum 74-18. Logan, UT: Ecology Center, Utah State University. 10 p.

Precipitation during the study period was somewhat deficient, and infiltrated soil moisture barely reached the 3 m depth. Results were limited to moisture changes within this 3-m soil depth. The pattern of soil moisture use by velvet mesquite was high during spring (April to June) and summer (July to September), and low during fall (October to December) and winter (January to March). Roots withdrew soil water first from areas close to the tap root and at shallower depths. As the growing season advanced and available moisture decreased, roots withdrew increasing proportions of water from areas increasingly farther away from the trunk (to at least 19.3 m) and from increasingly deeper soil layers. During the growing season (April to September), rates of soil water extraction differed strongly with horizontal distance from the trunk of the tree. Rates of extraction within the layer of active moisture withdrawal differed little at different depths, although the active water-withdrawal layer became increasingly thicker as the season advanced.

39. Cable, Dwight R. 1975. Influence of precipitation on perennial grass production in the semidesert southwest. Ecology. 56: 981-986.

Perennial grass production in the semidesert grass-shrub type (with and without a velvet mesquite [*Prosopis juliflora* var. *velutina* (Woot.1 Sarg.] overstory) was dependent primarily on current summer rainfall and previous summer rainfall. The influence of previous summer rainfall was an interaction effect--not a direct effect. The best overall relationship involved current August rainfall, previous June through September rainfall, and the interaction product of these two. However, the interaction product alone yielded estimates essentially as good as the multiple regression, and explained 64-91% of the year-to-year variability in grass production. Winter precipitation had no consistent effect on perennial grass production the following summer. The depressing effect of mesquite on perennial grass production was most noticeable at low rainfall levels and became minor at high rainfall levels.

40. Cable, Dwight R. 1976. Twenty years of changes in grass production following mesquite control and reseeding. Journal of Range Management. 29(4): 286-289.

Production of native perennial grasses and seeded lehmann lovegrass was measured periodically for 21 years on a semidesert area where velvet mesquite was controlled by 2,4,5-T aerial spray and on an adjacent unsprayed area to determine how mesquite control would affect grass production and how long the effect would last. Grass production on the sprayed area increased dramatically during the first 5 years in a time-dependent relationship in response to the higher levels of available soil moisture. During the last 12 years, changes in lovegrass production were associated with changes in rainfall of the current and previous summers and of the intervening winter (two separate variables). Because of the strong competition from lovegrass, native grass production during the last 12 years did not show its usual relationship with summer rainfall, but decreased gradually and consistently on both the sprayed and unsprayed areas. At the end of the study period, native grasses provided only 10% of the total perennial grass production on the sprayed area and 20% on the unsprayed. Increased grass production, resulting from the mesquite control treatment and seeding, paid for the treatment within 4 years, and the sprayed area was still producing more grass than the unsprayed area 20 years later.

41. Cable, Dwight R. 1977. Seasonal use of soil water by mature velvet mesquite. Journal of Range Management. 30(1): 4-11.

Mesquites used water consistently to a depth of 3 m and outward to 10 m beyond the crowns, but use at 15 m was limited mainly to drier periods when water supplies closer to the trees were depleted. With the start of spring growth, water was extracted most rapidly from the surface layers. As the season advanced, the water supply zone became increasingly thicker. Rates of extraction were highest immediately after recharge in early spring and early summer, and lowest in late fall. Differences in available water in the soil accounted for 72-88% of the variation in rates of extraction. The competitive effect of velvet mesquite on perennial grasses is most severe in the upper 37.5 cm of soil under and near the mesquite crowns, and it gradually decreases with distance into adjacent openings. The competitive effect in the openings is much more severe in dry years than in wet years.

42. Cable, Dwight R. 1979. Ecology of Arizona cottontop. Research Paper RM-209. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 21 p.

This paper summarizes what is now known about the ecology and management of Arizona cottontop (*Trichachne californica*), a palatable, drought-hardy, perennial grass that thrives under moderate grazing on semidesert ranges of the Southwest. Perennial culms that produce axillary shoots and have favorable response to grazing, long life, and ability to grow both on warm and cool season moisture are valuable attributes of this species.

43. Cable, Dwight R. 1980. Seasonal patterns of soil water recharge and extraction on semidesert ranges. Journal of Range Management.22(1): 9-15.

Soil water is recharged in the semidesert Southwest during the usual winter precipitation season and again during the usual summer rainy season. The amount and depth of recharge varies widely, depending primarily on the amount of precipitation and secondarily on storm character, soil texture, vegetation cover, and evapotranspiration. Soil water depletion patterns and amounts differed among species. between plants and bare soil, and between seasons. Compared to evaporation from bare soil, water extraction by plants was much faster but at more variable rates. Essentially all available soil water was used by plants or evaporated during most depletion periods.

44. Cable, Dwight R.; Bohning, John W. 1959. Changes in grazing use and herbage moisture content of three exotic lovegrasses and some native grasses. Journal of Range Management. 12(4): 200-203.

Cattle preferred Arizona cottontop earlier in the season, September through June, than any of the lovegrasses. Utilization of lehmann lovegrass lagged behind all other species until late in the spring. Otherwise the general patterns of use of the native and introduced grasses were similar. The results suggest that management of a semidesert, grass-shrub range with a mixture of native grasses and lovegrasses should be no more difficult than managing for native perennials alone.

45. Cable, Dwight R.; Martin, S. Clark. 1964. Forage production and stocking rates on southern Arizona ranges can be improved. Research Note RM-30. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 11 p.

Changes in vegetation were caused by three main factors: year-to-year variation in precipitation, management practices, and mesquite control.

46. Cable, Dwight R.; Martin, S. Clark. 1975. Vegetation responses to grazing, rainfall, site condition, and mesquite control on semidesert range. Research Paper RM-149. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 24 p.

Changes in herbage production, basal intercept, and grazing use of perennial grasses, herbage production of annual grasses, and crown intercept of shrubs and trees were related to changes in rainfall, presence or absence of velvet mesquite, and to differences in soil, topography, and salting. Over a 10-year period, mesquite control increased perennial grass production 52%. Perennial grass production was highly dependent on both last and current summer rainfall, indicating that 2 years are required for recovery from a 1-year drought. Too heavy use greatly restricted production in wet years that followed dry years. Because of the strong relationship between rainfall and grass production, stocking rates could be estimated as accurately from rainfall as from grass production.

47. Cable, Dwight R.; Shumway, R. Phil. 1966. Crude protein in rumen contents and in forage. Journal of Range Management. 19(3): 124-128.

Rumen-fistulated steers consistently selected a diet higher in crude protein than hand-clipped samples of the major available perennial grasses. The excess of rumen protein over grass protein depended on the availability of higher-protein shrubs and annual forbs that supplemented the perennial grasses, and on selection of high-protein parts of the grasses. Since the abundance of these high-protein forages varied greatly with time, the protein content of grass clippings did not reliably indicate the protein level in the steers' diet.

48. Cable, Dwight R.; Tschirley, Fred H. 1961. Responses of native and introduced grasses following aerial spraying of velvet mesquite in southern Arizona. Journal of Range Management. 14(3): 155-159.

Aerial spraying of velvet mesquite in two successive years with 2,4,5-T killed 36-58% of the trees and reduced mesquite foliage 86-95%. Increased herbage production of perennial grasses more than paid the treatment cost within 3 years.

49. Calder, W. A. 1968. The diurnal activity of the roadrunner (*Ceococcyx californianus*). Condor. 70(1): 84-85.

Findings suggest the roadrunner relies upon behavioral and ecological means rather than special physiological capacities for surviving desert conditions.

50. Calder, William A. 1968. There really is a roadrunner. Natural History. 77: 50-55.

This study presents information on physiology, metabolism, and life history of *Geococcyx californianus*.

51. Calvo, Susanna S. 1980. Scarps on the Madera Canyon alluvial fan: evidence for quaternary tectonism? *In:* Geosciences Daze, Eighth Annual Colloquium. 1980 March 5-7; Tucson, AZ: Department of Geosciences, University of Arizona: 5 p.

A description of a study of two scarps of 2-3 inches in height involving seismic work, stratigraphic mapping, and topographic surveys of scarp morphology is presented.

52. Canfield, R. H. 1942a. The relative grazing preference of cattle for the common semidesert grasses in southern Arizona. Research Note RM-102. Tucson, AZ: U.S. Department of Agriculture, Forest Service, Southwestern Forest and Range Experiment Station. 3 p.

There is a clearly defined normal tendency of cattle to graze some plants at a height of 2 inches or less. A 15-25% balance of ungrazed forage at the close of the grazing season is recommended. Any attempts to fully utilize 75-85% of low preference grasses would result in overuse of preferred grasses. Tanglehead and bush muhly supply valuable forage during drought periods.

53. Canfield, R. H. 1942b. Sampling ranges by the line interception method: plant cover, composition, density, degree of forage use. Research Report 4. Tucson, AZ: U.S. Department of Agriculture, Forest Service, Southwestern Forest and Range Experiment Station. 28 p.

A complete description of the method is provided, with additional emphasis on sampling units and data analysis.

54. Canfield, R. H. 1942c. A short-cut method for estimating grazing use. Research Note 99. Tucson, AZ: U.S. Department of Agriculture, Forest Service, Southwestern Forest and Range Experiment Station. 5 p.

The method utilizes the relationship existing between the amount of a grass stand grazed to a stubble height of 2 inches or less, the amount grazed above a 2-inch stubble height, and the ungrazed complement. Advantages and disadvantages are discussed.

55. Canfield, R. H. 1943. What is conservation grazing? A question every ranchman should be vitally interested in. The Cattleman. 30: 16, 18.

Under conservative grazing, 50-75% of palatable species in a normal year would remain unused at the close of the grazing period.

56. Canfield, R. H. 1944a. Measurement of grazing use by the line interception method. Journal of Forestry. 42(3): 192-194.

Field experience in the Southwest has demonstrated the suitability of the line interception method for combining the measurement of utilization with plant density and composition estimates. It includes the advantages of actual measurement and random sampling. Moreover, the data obtained lend themselves readily to statistical analysis. The method operates equally well in sampling both large and small pastures.

57. Canfield, R. H. 1944b. A short-cut method for checking degree of forage utilization. Journal of Forestry. 42(4): 192-194.

The method is based on the relationship of the percentage of close grazing to the percentage of total use. The method can be learned in short time and yields results within 10% accuracy.

58. Canfield, R. H. 1948. Perennial grass composition as an indicator of condition of southwestern mixed grass ranges. Ecology. 29(2): 190-204.

Composition of the perennial grass population of mesa and foothill types of semidesert grassland range varied significantly with the general intensity of grazing to which they are commonly subjected. Relative amounts of common perennial grasses showed the early changes toward range recovery or toward range deterioration better than any other indicator.

When the productivity of the range has not been greatly impaired by prolonged overuse and erosion, the rate of range recovery under conservative grazing was approximately equal to the recovery rate obtained under total protection from grazing by domestic livestock.

Tall, coarse-stemmed grasses such as Arizona cottongrass, sideoats grama, and black grama attained a high percentage of the total perennial grass cover under long periods of protection.

Populations of relatively unpalatable deep rooted shrubs and trees were comparatively slow to change in response to conservative grazing or to total protection from grazing by cattle.

59. Canfield, R. H. 1957. Reproduction and life span of some perennial grasses of southern Arizona. Journal of Range Management. 10(5): 199-203.

Primary forage grasses were more abundant on areas that received light or no grazing. Both secondary and primary grasses produced new plants each year, but secondary species usually produced greater numbers. Some black grama plants survived as long as 14 years, but Rothrock grama lived only 3 years.

60. Caraher, David Luther. 1970. Effects of longtime livestock exclusion versus grazing on the desert grassland of Arizona. Tucson, AZ: University of Arizona. 45 p. M.S. thesis.

Plant cover did not vary significantly among grazing treatments. Cover of mesquite reflected distribution before treatments. Total grass cover appeared to vary inversely with mesquite cover. Cover of lehmann lovegrass was more dependent on the distribution of native plants than grazing treatments.

61. **Carr, Richard Vance. 1972. The tergal gland and courtship behavior in the termites *Pterotermes occidentis, Marginitermes hubbardi*, and *Paraneotermes simplicicornis (Isoptera: Kalotermitidae)*. Tucson, AZ: Department of Entomology, University of Arizona. 93 p. Ph.D. dissertation.**

Courtship behavior was related to the presence of tergal glands in the alates. In *Paraneotermes* it was found that the presence of tergal glands in both sexes, and probable production of a sex pheromone by these glands, could be related to the different activities in their courtship repertoires. This was not the case with *Pterotermes* and *Marginitermes*.

62. **Carter, Fairie Lyn; Stringer, Charles A. 1970a. Residues and degradation products of technical heptachlor in various soil types. Journal of Economic Entomology. 63(2): 625-628.**

The persistence and degradation of heptachlor varied considerably by location in tests in five areas of the United States. Relatively high values for 1-hydroxy-chlordene, representing approximately 60% of the insecticide in the soil, were obtained for extracts of a Quincy loamy fine sand from Oregon. Significant amounts of 1-hydroxy-chlordene were found in the extracts of Lakeland sand from Florida. Generally, heptachlor epoxide represented only a small fraction of the insecticide present in the soil.

63. **Carter, Fairie Lyn; Stringer, Charles A. 1970b. Soil moisture and soil type influence initial penetration by organochlorine insecticides. Bulletin of Environmental Contamination and Toxicology. 5(5): 422-428.**

Because present recommendations for termite control by soil application of chlorinated hydrocarbons were developed on soils and for termites in southern Mississippi, field tests were established at seven locations to compare control of the various species of termites in different soils and climates. In the upper 4 inches of soil, the amount and distribution of insecticide residues and degradation products varied considerably for the different locations 3 years after application. Differences in initial penetration may have been a major cause for this variation. In 24 hours the insecticide emulsions penetrated least in arid soils in Arizona and Oregon and most in wet soil from Missouri. This paper reports the results of laboratory studies into the factors influencing soil penetration by insecticides. A mixture of aldrin, dieldrin, and heptachlor was applied as a water emulsion to columns of soil obtained from the field test locations.

64. **Carter, Fairie Lyn; Stringer, Charles A. 1971. Soil persistence of termite insecticides. Pest Control. 39(2): 13-14, 16, 18, 22, 29.**

Differences in persistence and degradation of chlorinated hydrocarbons attributable to differences in soil properties were observed after 1 year of weathering. More insecticide was lost from surface layers than from lower soil layers. Heptachlor was affected most by weathering.

65. **Carter, Fairie Lyn; Stringer, Charles A.; Beal, Raymond H. 1970. Penetration and persistence of soil insecticides used for termite control. Pest Control. 38(10): 18-22.**

Variations in penetration and persistence of aldrin, chlordane, dieldrin and heptachlor in different soils and climates were found to be affected by soil types, soil moisture content, and climate and may subsequently influence the effectiveness of treatment.

66. **Cassady, John T.; Glendening, George E. 1940. Revegetating semidesert range lands in the southwest. Forestry Publication No. 8. Washington, DC: U.S. Federal Security Agency, Civilian Conservation Corps. 21 p.**

The information, procedure, and methods outlined are based on the results of systematic studies in New Mexico and Arizona (SRER). Various methods of plant establishment are discussed.

67. **Clary, Warren P. 1975. Ecotypic adaptation in *Sitanion hystrix*. Ecology. 56: 1407-1415.**

Ecotypic differentiation as a response to climatic conditions was studied in an adaptable grass species, *Sitanion hystrix* (Nutt.) J. G. Smith. Twelve collections were obtained from seven states: Arizona, Colorado, Nebraska, Nevada, New Mexico, South Dakota, and Utah. The collection sites varied in elevation from 1,380 to 2,980 m and in annual precipitation from 310 to 739 mm. Plant materials were grown under uniform conditions in a transplant garden and a growth chamber.

The effective growing seasons at the original collection sites were apparently as limited by moisture stress as by cold temperatures. Relative phenological development could be predicted by a climatic scale representing temperature and moisture conditions at the original collection sites. Plant size and dry matter production could not be predicted as reliably, suggesting that the primary factors that influence morphological and production characteristics may be more numerous or complex than those that influence phenology.

The populations represented in this study have adapted to different climatic conditions primarily through variations in timing of phenological development and in rate of growth. No differences in water use efficiency were found. Under uniform conditions: (1) plants from warm, dry habitats flowered early and had low dry matter production; (2) plants from habitats with moderate temperature and moisture conditions flowered latest and had relatively high dry matter production; and (3) plants from cool, wet habitats flowered early and had relatively high dry matter production. Flowering dates of the different collections varied as much as 2 months.

68. Clemmons, Stan; Wheeler, L.D. 1970. Soils report: Santa Rita Experimental Range, Coronado National Forest. Albuquerque, NM: U.S. Department of Agriculture, Forest Service, Southwestern Region. 41 p.

Soils are described as individual mapping units and technical profile descriptions are given for each soil.

69. Courtney, Mark William. 1971. Effects of removal on movements within populations of nocturnal desert rodents. Tucson, AZ: University of Arizona. 32 p. M.S. thesis.

Areas of activity included the point of removal, initially, but with time the distance between removal and activity area tended to increase. Results indicate that live-traps restricted the normal activity patterns of some animals, and that neither snap-traps nor live-traps capture all individuals in the area.

70. Courtney, Mark William. 1983. Effects of reduced interspecific interactions on population dynamics in merriam's kangaroo rat, *Dipodomys merriami*. Tucson, AZ: University of Arizona. 73 p. Ph.D. dissertation.

Nocturnal rodents were censused every 2 weeks on two, 1.69 ha (4.13 ac) live-trap grids. All nocturnal rodents except *Dipodomys merriami* were removed from one of the grids. Effects on the population biology of *D. merriami* were subsequently analyzed. Removal caused no significant effect on home range. Mean weight for both reproductively active and inactive males and females was not significantly different following removal.

71. Cox, Jerry R.; Martin-R., Martha H. 1984. Effects of planting depth and soil texture on the emergence of four lovegrasses. Journal of Range Management. 37(3): 204-205.

The emergence of 4 lovegrasses planted at 0.0, 0.5, 1.0, 1.5 and 2.0 cm depths in Pima silty clay loam, Sonoita silty clay loam, and Comoro sandy loam soils were studied in a greenhouse. Catalina boer lovegrass emergence was superior in all soils and at all depths. Approximately 75% of the radicles of germinating Lehmann and A-84 boer lovegrass seeds failed to penetrate the surface of the three soils when surface sown. Lehmann lovegrass seed planted below the surface failed to emerge in the three soils.

72. Cox, Jerry R.; Martin-R., Martha H.; Ibarra-F., Fernando A.; Morton, Howard L. 1986. Establishment of range grasses on various seedbeds at creosotebush (*Larrea tridentata*) sites in Arizona, U.S.A., and Chihuahua, Mexico. Journal of Range Management. 39(6): 540-546.

Perennial grasses were seeded by drilling or broadcasting on four mechanical and three herbicidal weed control and/or seedbed preparation treatments at four semidesert grassland sites invaded by creosotebush. The cultivars, "Cochise" Atherstone lovegrass and "Catalina" Boer lovegrass, were initially established and persisted in six of the eight plantings on disk plowed and disk plowed plus contour furrowed seedbeds. These grasses were established and persisted in two of the five plantings made in creosotebush stands treated with herbicides. Grasses established initially on two-way railed and land imprinted areas usually died within 3 or 4 years.

73. Cox, J. R.; Roundy, G.B. 1986. Influence of climactic and edaphic factors on the distribution of *Eragrostis lehmanniana* Nees in Arizona, USA. Journal Grassland Society of South Africa. 3(1): 25-29.

Lehmann lovegrass was introduced into Arizona from South Africa in 1932 and has since been sown throughout the southwestern USA and northern Mexico. The species is well adapted in southeastern Arizona where it has been sown on over 69,115 hectares and has spread by seed to an additional 76,040 hectares. Where lehmann lovegrass predominates and spreads, surface soils are sandy, summer rainfall is greater than or equal to 200 mm and winter temperatures rarely fall below 0°C. Factors contributing to the spread of lehmann lovegrass include fire, cattle grazing, and drought.

74. Crafts, Edward C. 1938a. Experimental ranges and other range research centers of the Forest Service. Tucson, AZ: U.S. Department of Agriculture, Forest Service, Southwestern Forest and Range Experiment Station. 15 p.

Describes the establishment and work function of various experiment stations in the West.

75. Crafts, Edward C. 1938b. Height-volume distribution in range grasses. Journal of Forestry. 36(12): 1182-1185.

There are 137 million acres of usable range in Arizona and New Mexico, and livestock production is an outstanding industry in the Southwest. Basic resources of this industry are the soils and the vegetation they support. Continued production of range grasses is, in a large measure, dependent on forage utilization. The importance of knowing what constitutes proper use of a given kind of grass and of having an accurate method of measuring its utilization becomes evident when one realizes that a 10% variation in the use of the herbage volume may result in continued productivity or gradual death of the plant.

76. Crafts, Edward C. 1941. A plan for insurance against drought on the range lands of Arizona and New Mexico. Ann Arbor, MI: School of Forestry and Conservation, University of Michigan. 166 p. Ph.D. dissertation.

A successful insurance practice would service the industry by eliminating risk of drought and substituting a known budgetable annual expense, by wiping out over-

stocking on insured properties, by easing credit facilities through the use of insurance as loan collateral and to lower interest rates, and by contributing to increased security in the business enterprise through its more efficient conduct, greater peace of mind, and general stabilization of the ranch economy.

77. Crafts, Edward C.; Glendening, George E. 1942. How to graze blue grama on southwestern ranges. Leaflet 215. Washington, DC: U.S. Department of Agriculture. 8 p.

On 48 million acres in Arizona and New Mexico, or more than a third of the total usable range in these states, as well as on ranges in adjacent Texas, blue grama is the dominant forage plant. Throughout this region, which is here loosely termed the Southwest, blue grama is of primary importance on 13 national forests, on other public lands, and on great areas of private range.

There are three outstanding reasons for this superiority. Blue grama provides excellent forage, is highly resistant to grazing and drought, and is an effective soil binder. To a considerable degree the welfare of the livestock industry in the Southwest is dependent upon maintaining the dominance of blue grama and the further protection and extension of present well-established stands. For these reasons a widespread understanding of the simple principles of utilization and management required to maintain this high-grade forage and to make the most of its soil-protective characteristics is highly desirable.

78. Cribbs, W. J. 1938. Burroweed control on southwestern ranges. Arizona Stockman. Jan. 4-5.

Preliminary recommendations regarding various control methods of burroweed are discussed. Notes on the growth and development are included.

79. Culley, Matt. 1937. How to get sustained forage production in grazing semidesert mixed grass ranges. Western Livestock Journal. 15(23): 5-6.

Results of a 9-year study showed that: (1) on the average, most of the common semidesert range grasses in southern Arizona can be grazed safely within 2 inches of the ground; (2) black grama, an exception to this rule, cannot be grazed closer than 3 inches above the ground; (3) moderate-heavy grazing should be limited during drought years; (4) deficient rainfall coupled with continuous close grazing results in very large reductions in both stand and yield of forage; and (5) sustained or proper grazing capacity should approximate 20% below the capacity of the range under forage conditions of the average year.

80. Culley, Matt. 1938a. Densimeter, an instrument for measuring the density of ground cover. Ecology. 19(4): 588-590.

A procedure is outlined for determination of total plant density. A device called a densimeter is utilized to record density on variable sized quadrats.

81. Culley, Matt. 1938b. Grazing habits of range cattle. The Cattleman. 24: 19-23. [Also in The Hereford Journal. January: 18,19,22.].

This study reports on the grazing habits of cattle, their forage preferences, diurnal and nocturnal activities, factors affecting distribution, and factors that influence grazing behavior.

82. Culley, Matt. 1938c. Grazing habits of range cattle. American Cattle Producer. 20(1): 3, 4, 16, 17.

Preliminary findings showed most of the Santa Rita grasses, along with a few shrubs, were grazed consistently during all seasons of the year. Some grasses were preferred for short periods on varied sites. California poppy and Indian wheat were preferred whenever they were available. Shrub use was varied. Grazing periods averaged between 7 and 8 hours during the summer and winter and averaged about 9 hours in spring. Temperature and forage condition influenced grazing behavior.

83. Culley, Matt. 1938d. Planning for range improvements. American Cattle Producer. 20(3): 3-4. [Also in Western Livestock Journal. August 16(34):8. New Mexico Stockman. August: 8-9.].

Three major factors, investment load per cow, proper location of improvements, and adequacy of range improvements, are essential to advance planning.

84. Culley, Matt. 1939a. The decagon for vegetation studies. Journal of Forestry. 37(6): 492-493.

The decagon is a 10 square-foot sampling quadrat divided into 10 equal triangular segments. Density estimates of each segment are calculated separately. The statistical advantage is that each plot provides 10 samples instead of one. This technique is best suited for research where a certain degree of accuracy must be observed.

85. Culley, Matt. 1939b. Rodents or cattle? Western Livestock Journal. 17(19): 30-31.

Results of an intensive rodent study showed that total amount of vegetation eaten by the principal rodents amounted to over 2.9 million pounds (1,450 tons) yearly, or the equivalent consumption of 206 head of cattle yearlong. Rodents damaged perennial grass roots, stalks, and seedheads, and they denuded considerable areas around their dens. Some benefits from rodents were realized.

86. Culley, Matt. 1943a. Grass grows in summer or not at all. American Hereford Journal. 34(9): 8, 10.

Rains of less than 0.4 inch were largely ineffective insofar as affecting the growth of range forage grasses, unless they occurred for several days in succession and were preceded or succeeded by rains of greater amounts. Summer growth was expected after July 10. The growing season was about 9 weeks. Approximately 93% of perennial grass yield was produced during summer growth.

87. **Culley, Matt. 1943b. Proper stocking pays dividends. Western Livestock Journal. 28(1): 7.**

A 20-year assessment of the factors responsible for increased financial returns revealed that conservative stocking was the major influence. Other contributing factors included use of good bulls, critical culling of breeding cows and careful selection of heifer replacements.

88. **Culley, Matt. 1946a. Factors affecting range calf crop. Arizona Stockman. 12(10): 30-37.**

In a 30-year assessment period, 13 factors were considered as major factors affecting calf production. Condition of breeding herd and size of breeding pastures were two major factors.

89. **Culley, Matt. 1946b. Good range cattle. Arizona Cattlelog. 1(10): 3-6; and 1(11): 12-14.**

Important factors involved in raising better cattle include: (1) knowledge of latest research and methods of livestock production, (2) livestock shows, and (3) ranch demonstrations of new innovations. The main requirements for a good breeding herd are outlined.

90. **Culley, Matt. 1946c. Quality cattle for profit. American Hereford Journal. 37(11): 8-9, 168-169.**

Improvement in grade of cattle is achievable by using better bulls, providing adequate range forage yearlong, more critical culling of breeding stock, and greater care in selection of replacement heifers.

91. **Culley, Matt. 1947. It pays to be loss conscious. The Cattleman. 34(7): 25-26, 52, 55.**

The answer to the death loss problem on the range is adequate supervision that: (1) recognizes the need for a conservative stocking rate, (2) is fully conscious of actual cost of losses, (3) gets at the underlying causes of losses, and (4) constantly strives to prevent and remedy them.

92. **Culley, Matt. 1948. Modern business methods in handling range cattle. Arizona Stockman. 14(4): 13, 26-27.**

Modern methods of handling cattle are discussed.

93. **Culley, Matt J. 1937a. An economic study of cattle business on a southwestern semidesert range. Circular 448. Washington, DC: U.S. Department of Agriculture. 24 p.**

When all operation expenses are considered, it cost an average of $25.11 to produce an 8- or 9-month-old calf. The calf crop averaged 82.7%, based on the number of cows in the breeding herd. Cattle losses averaged 2.8% annually, while calf losses were 2.9%, mostly from unknown causes. Range practices that materially increased herd earnings were: (1) stocking on the basis of sustained yield; (2) regular fall-winter sales of high-grade calves; (3) reduction of carry-overs, horses, and aged steers to the minimum; and (4) leaving an equivalent of at least 15% of the forage as a drought safety factor. Recent findings have shown that a 20% reserve would be better. An average calf crop of 44% was necessary to recover cash expenditures. A calf crop greater than 56% was necessary for profits.

94. **Culley, Matt J. 1937b. Grazing habits of range cattle. Research Note 21. Tucson, AZ: U.S. Department of Agriculture, Forest Service, Southwestern Forest and Range Experiment Station. 4 p.**

Range areas on which annual grasses and weeds are the dominant vegetation should be grazed to obtain full use during the summer and spring growing seasons. Areas where tanglehead, cottongrass, or California threeawn are dominant can be grazed to best advantage during the winter and late spring, since they normally furnish a relatively greater amount of green feed at these seasons than most other range grasses. Black grama areas are chiefly valuable for grazing during the winter or spring and do best when protected or subject to only light grazing during the summer growing season. Mesquite and catclaw areas can be grazed to best advantage during the winter.

Guajilla and range ratany are relished by cattle throughout most of the year; however, where abundant they can be used to best advantage during the spring when perennial grasses are dry or largely grazed off. Most of the remaining common grasses and small shrubs are grazed by cattle with equal relish throughout the year and no particular advantage is to be gained by attempting to use them at any specific season.

Lack of adequate salting may have its serious side since cattle deprived of salt may attempt to satisfy their craving at a dirt salt lick and may die as a result.

95. **Culley, Matt J. 1941. Does it rain less now than in the old days? Western Livestock Journal. 19(44): 5, 78.**

Long-term precipitation records are compared with recent drought periods.

96. **Culley, Matt J. 1942. Thirty years ago and now in Arizona cattledom. Western Livestock Journal. 28(2): 43.**

A comparative summary of the livestock business from 1910 to 1940 is provided.

97. **Culley, Matt J.; Campbell, R.S.; Canfield, R.H. 1933. Values and limitations of clipped quadrats. Ecology. 14(1): 35-39.**

Clipping treatments failed to simulate grazing by livestock, but in spite of the differences, clipped quadrats can be of immense value to actual grazing studies. Results can be obtained at rather low costs to show the comparative maintenance, yield, and quality of forage species under known varying intensities of harvesting, with the effects of given amounts and character of rainfall upon production. The method aided greatly in the determination of correct utilization of range and pasture forage--a vital feature for the proper conservation of forage and watershed resources.

When used with perfected techniques and judicious interpretation of results, it should prove to be even more valuable than it has been in the past.

98. Danner, Dennis A.; Fisher, Alan R. 1977. Evidence of homing by a coyote (*Canis latrans*). Journal of Mammalogy. 58(2): 245.

An adult male coyote captured on SRER was transported 48 km away and observed to return to its capture site.

99. Danner, Dennis A.; Smith, Norman S. 1980. Coyote home range, movement and relative abundance near a cattle feed yard. Journal of Wildlife Management. 44(2): 484-487.

The data suggest that the use of the carcass area enlarged home ranges of adult coyotes, but not those of pups and yearlings. Immature coyotes appeared to be more dependent upon the carrion than adults.

100. Danner, Dennis Alan. 1976. Coyote home range, social organization, and post visitation. Tucson, AZ: University of Arizona. 86 p. M.S. thesis.

Home range areas averaged 2.1 (irregular polygon) and 29.3 (ellipse) square miles for adults and 2.6 (irregular polygon) and 3.7 (ellipse) for immature coyotes. Behavioral observations, sightings of groups, and interactions were used to assess coyote sociability. Average group size was 1.4 and several coyotes formed temporary associations. A carcass area may have increased home ranges of several adults and attracted coyotes from more than 9 miles away. Pups may have been more dependent on the carcass area for their food source.

101. Darrow, Robert A. 1935. Study of the transpiration rates of several desert grasses and shrubs as related to environmental conditions and stomatal periodicity. Tucson, AZ: University of Arizona. 116 p. M.S. thesis.

Stomatal periodicities of Rothrock's grama and black grama were found to be quite similar. Maximum stomatal opening occurred between 2 p.m. and 4 p.m., and partial opening was evident throughout the night. Cotton grass showed a close correlation between stomatal periodicity and transpiration.

102. de Andrade, Ivo Francisco. 1979. Growth response of sideoats grama to seasonal herbage removal and competition from adjacent vegetation. Tucson, AZ: School of Renewable Natural Resources, University of Arizona. 90 p. Ph.D. dissertation.

Plants clipped the previous summer made greater root growth than above ground growth in the spring following clipping. Clipping in both spring and spring-plus-summer resulted in a temporary reduction in concentration of total nonstructural carbohydrate in roots and above ground parts.

103. de Oliveira, Jose Gerardo Beserra. 1979. Characterization of range sites. Tucson, AZ: School of Renewable Natural Resources, University of Arizona. 105 p. Ph.D. dissertation.

Range sites were identified using soil and vegetation data from combinations of strata of two precipitation zones, three groups of soils, and three levels of historical grazing use. *Bouteloua rothrockii* and *Trichachne californica* were not useful site indicators but were useful indicators in utilization studies. Seven sites were identified from cluster analysis of the soils and ordinated according to trends in permeability, available water capacity, clay content, and thickness of surface layers.

104. Diskin, M. H.; Lane, L. J. 1976. Application of a double triangle unit hydrograph to a small semi-arid watershed. Journal of the Arizona Academy of Science. Abstract 309, Proceedings supplement: 108.

Rainfall and runoff data for a number of storm events on a small watershed were analyzed. Double triangle unit hydrographs were fitted to individual storm events. The differences in the shapes of individual unit hydrographs were found to be small so that they could be approximated by a single double triangle unit hydrograph.

105. Drewek, John, Jr. 1980. Behavior, population structure, parasitism, and other aspects of coyote ecology in southern Arizona. Tucson, AZ: Department of Biological Sciences, University of Arizona. 277 p. Ph.D. dissertation.

Minimum home ranges for 6 radio-tracked coyotes ranged in size from 0.5 to 7.9 square miles. Females tended to occupy larger areas than did males. Age distribution of 378 coyotes was based on annual counts from canine teeth. Average age was 3.2 years. Of 273 known-sex coyotes, the ratio was 154 males: 119 females. Males tended to outlive females. Over 100 coyote specimens were examined for parasites. Coyotes selected a greater percentage of smaller mammals (35%) in their diet than larger mammals (25.4%), birds (16.4%), vegetable matter (16.2%), invertebrate (6.4%), or reptiles (0.1%).

106. Drewes, Harald. 1971a. Geologic map of the Sahuarita quadrangle, southeast of Tucson, Pima County, Arizona. Miscellaneous Geological Investigation Map No. I-613, scale 1:48,000. Washington, DC: U.S. Department of the Interior, Geological Survey.

The map delineates the major geological formations of the area.

107. Drewes, Harald. 1971b. Mesozoic stratigraphy of the Santa Rita Mountains, southeast of Tucson, Arizona. Professional Paper 658-C. Washington, DC: U.S. Department of the Interior, Geological Survey. 81 p.

The Santa Rita Mountains consist of complex deformed sedimentary, volcanic, and intrusive rocks of Precambrian

through Cenozoic ages. The Mesozoic rocks comprise 12 formations, have a cumulative thickness of more than 30,000 feet, and represent parts of at least the Triassic and Cretaceous Periods. These rocks were almost all deposited subaerially, many of them in basins associated with block faulting or volcanism or both, but others were deposited in a more gently downwarped basin. The rocks of the Late Cretaceous show signs of increasing orogenic activity, and the deposition sequence described here ends at the close of that period with the intrusion of large plutons. Fossils from two of the formations and isotopic dates from six of them augment the geologic field relations to provide a framework for the interpretation of the geologic development of the area through the Mesozoic.

108.

Drewes, Harald. 1972a. Cenozoic rocks of the Santa Rita Mountains southeast of Tucson, Arizona. Professional Paper No. 746. Washington, DC: U.S. Department of the Interior, Geological Survey. 66 p.

A description of the stratigraphy and petrography of the Cenozoic rocks and interpretation of their environments of deposition or emplacement are discussed.

109. **Drewes, Harald. 1972b. Structural geology of the Santa Rita Mountains, southeast of Tucson, Arizona. Professional Paper No. 748. Washington DC: U.S. Department of the Interior, Geological Survey. 35 p.**

The major structural features are described and serve as a discussion for understanding the regional tectonic development of the area.

110. **Drewes, Harald. 1973. Geochemical reconnaissance of the Santa Rita Mountains, southeast of Tucson, Arizona. Bulletin No. 1365. Washington, DC: U.S. Department of the Interior, Geological Survey. 67 p.**

This study revealed that base metals, noble metals, and some other rare metals have been mobilized and have accumulated locally near certain rocks or structural features. Some geochemical anomalies delineate known mining camps; others suggest additional exploration targets. Several targets are reviewed.

111. **Eddy, Thomas A. 1959. Foods of the collared peccary, *Pecari tajacu sonoriensis* (Mearns), in southern Arizona. Tucson, AZ: Wildlife Management Department, University of Arizona. 102 p. M.S. thesis.**

Prickly pear cladophylls and fruits were the major food items in the palo verde-bursage cacti vegetative type, and prickly pear and century plants were the major food items in the desert-grassland type. Century plants, tubers, and acorns were important in the oak-grassland types. Succulent forbs were preferred. Seasonal feeding activity patterns were noted. Significant competition between livestock and peccaries was not noted.

112.

Eddy, Thomas A. 1961. Foods and feeding patterns of the collared peccary in southern Arizona. Journal of Wildlife Management. 25: 248-259.

Prickly pear pads and fruits were the major food items in the palo verde-bursage-cacti vegetative type. Prickly pear and century plants were the most important foods in the desert-grassland vegetative type. Century plants and tubers made up the bulk of the peccaries' diet in the oak-grassland vegetative type. Cactus fruits, beans, berries, and annual forbs provided valuable seasonal supplements in the peccaries' diet.

113. **Elmi, Ahmed Abdi. 1981. Phenology, root growth and root carbohydrates of Lehmann lovegrass (*Eragrostis lehmanniana*) in response to grazing. Tucson, AZ: University of Arizona. 58 p. M.S. thesis.**

Lehmann lovegrass responded to moisture conditions by increasing or decreasing shoot growth. Grazing treatments stimulated new shoot and root growth. Neither grazing treatment had detrimental effects compared to no grazing. The total accumulated carbohydrate reserves in roots showed quick response of lehmann lovegrass to grazing and moisture conditions. Rolled dry green leaves were noted during dry periods, a characteristic of the plant that allows moisture retention by reducing transpiration during water stress.

114. **Emmerich, William E.; Cox, Jerry R. 1992. Hydrologic characteristics immediately after seasonal burning on introduced and native grasslands. Journal of Range Management. 45(5): 4-476.**

Immediately after a burn there was not a significant change in runoff and erosion; therefore, vegetation cover by itself was concluded not to be a dominant factor in controlling surface runoff and erosion. The increase found in surface runoff and sediment production from the burn plots was not significantly greater than the natural variability for the locations or seasons. Significantly higher surface runoff and sediment production was measured in the fall season compared to the spring at one location.

115. **Fish, Ernest B.; Smith, Edwin L. 1973. Use of remote sensing for vegetation inventories in a desert shrub community. Progressive Agriculture in Arizona. 25(3): 3-5.**

Results indicated that initial subdivision of the study area into two subcommunities using 1:6000 scale imagery were in fact valid and that a quantitative measure of the differences is possible using 1:600 scale imagery. The imagery techniques, using approximately one-third as many sample units, adequately detected crown cover differences nearly as well as more intensive ground sampling.

116. Fisher, Alan Raymond. 1980. Influence of an abundant supply of carrion on population parameters of the coyote. Tucson, AZ: School of Renewable Natural Resources, University of Arizona. 94 p. Ph.D. dissertation.

No differences were observed among age distributions, weights, ovulation rates, and litter sizes of coyotes from three study areas. Visitation rates of coyotes, lagomorphs, and small mammals fluctuated greatly. Distribution of coyote and lagomorph visits along a scent station line remained unchanged after the summer of 1976, but small mammal visitation increased. The breeding rate remain unchanged after the carrion supply ended.

117. Follett, Edson Roy. 1962. The increase of cholla (*Opuntia fulgida* Engelm.) in relation to associated specieson a desert grassland range of southern Arizona. Tucson, AZ: University of Arizona. 28 p. M.S. thesis.

Perennial grasses and mesquite were determined to affect the growth and propagation of cholla. Increased percent ground cover of perennial grasses reduces the total number of cholla plants per acre. An inverse correlation exists between the total number of cholla plants per acre and crown cover of mesquite, while a positive correlation exists between the percentage of young cholla plants and crown cover of mesquite. Cholla crown cover has doubled during the last 20 years on some local areas.

118. Galt, H. D.; Ogden, Phil R.; Ehrenreich, J. H.; Theurer, Brent; Martin, S. Clark. 1968. Estimating botanical composition of forage samples from fistulated steers by a microscope point method. Journal of Range Management. 21(6): 397-401.

A microscope point method was used to develop weight prediction equations for plant species in masticated forage samples. With 400 microscope points, the average weight of a species was estimated within 5% of the mean at a 90% level of probability when the species constituted 30-60% of the sample weight.

119. Galt, H. D.; Theurer, Brent; Ehrenreich, J. H.; Hale, W. H.; Martin, S. Clark. 1966. Botanical composition of the diet of steers grazing a desert grassland range. Proceedings of the Western Section of the American Society of Animal Science. 17: 397-401.

Rumen-fistulated steers were employed to study the botanical composition of the diet on a desert grassland range. Botanical composition of the major plant species in the diet was determined on a qualitative and quantitative basis using a microscope point technique. The botanical composition of the diet changed greatly with time of year and was considerably different quantitatively compared to the available forage. Crude protein content of the rumen samples was considerably greater than the protein content of the whole hand-clipped major plant species identified in the rumen samples.

120. Galt, H. D.; Theurer, Brent; Ehrenreich, J. H.; Hale, W. H.; Martin, S. Clark. 1969. Botanical composition of diet of steers grazing a desert grassland range. Journal of Range Management. 22(1): 14-19.

Refer to Galt et al. 1966.

121. Galt, H. D.; Theurer, Brent; Martin, S. Clark. 1982. Botanical composition of steer diets on mesquite and mesquite-free desert grassland. Journal of Range Management. 35(3): 320-325.

Dietary composition of plant groups consisted of 67-97% grasses, 0-4% forbs, and trace to 33% shrubs. Species composition of diets varied by seasons and among animals. Plant preference was not necessarily related to plant availability. Composition of diets was markedly different from composition of pastures. Black grama averaged only 3% of diets but comprised about one-third of herbage production. Arizona cottontop, which averaged 20% of herbage on pastures, was the most consistently selected species, averaging 34% of the diet. Seasonal preference was shown for certain grasses such as rothrock grama in spring and bush muhly in winter. Highest preference for shrub species was shown in winter and early summer. Overall dietary composition between pastures was much the same, but average herbage production for a 2-year period was 347 kg/ha greater where mesquite had been controlled. Leaves comprised the major plant part of steer diets on both pastures. Leaf content of diets increased from winter to summer while stems decreased for the same periods.

122. Galt, Henry D. 1966. The botanical composition of steer diet on a semidesert range. Tucson, AZ: University of Arizona. 99 p. M.S. thesis.

The botanical composition of the diet varied both qualitatively and quantitatively with the time of the year. A great difference existed between the botanical composition of the pasture and rumen samples. The ocular estimate was only a general estimate of the animals' diet and the microscope point method estimated botanical composition of the diet with a reliable degree of accuracy.

123. Galt, Henry Deloss. 1972. Relationship of the botanical composition of steer diet to digestibility and forage intake on a desert grassland. Tucson, AZ: Department of Watershed Management, University of Arizona. 234 p. Ph.D. dissertation.

Species composition of the steer diets was different from composition of the available species. Arizona cottontop was the most consistently selected and predominant species in the diets. Shrubs were selected primarily in spring and summer. Selectivity was shown for certain plant parts. Apparent digestibility of dry matter, acid-detergent fiber, crude protein, and gross energy increased during the summer. Forage intake was significantly higher during summer. Total crude protein content was adequate for maintenance most seasons except winter.

124. Gamougoun, Ngartoina Dedjir. 1987. Cattle grazing behavior and range plant dynamics in southern Arizona. Tucson, AZ: Department of Nutritional Sciences, University of Arizona. 235 p. Ph.D. dissertation.

Forage biomass, nutrient value, botanical composition, and ground cover were greater in the growing season than in the dormant season. Moderate and heavy grazed pastures had lower plant parameters than very heavy grazed, except for forage biomass and lehmann lovegrass proportion, forage fiber and ground cover. Slopes and washes had a higher forage nutrient content and lower biomass and ground cover than uplands. Lehmann lovegrass was more abundant on the uplands and in the washes than on the slopes and the inverse was true for native species. Understory forages contained greater nutrients and forbs than open forages and the inverse occurred for shrubs and ground cover.

125. Gaspar, C.; Werner, F. G. 1976. The ants of Arizona: An ecological study of ants in the Sonoran Desert. US/IBPDesert Biome Research Memorandum 73-50. Logan, UT: Ecology Center, Utah State University. 14 p.

Thirty-seven different ant species were found at three sites: 18 at Silverbell, 21 at Santa Rita treated, and 33 at Santa Rita control. The qualitative and quantitative analyses of the ant fauna showed that these three sites were differentiated by a dense community of *Pheidole xerophila tucsonica* and *Pogonomyrmex pima* at Silverbell; by a significant community of *Pheidole xerophila tucsonica, Pheidole pilifera artemisia, Iridomyrmex pruinosum analis, Pheidole spadonia* and *Pogonomyrmex desertorum* at the Santa Rita treated site; and by an elevated community of *Crematogaster coarctata vermiculata* and *Forelius foetidus* at the Santa Rita control site. The sites are also differentiated by the number of nests present per hectare: Silverbell, 492; Santa Rita treated, 1926; and Santa Rita control, 1753. By an indirect method, used for the first time, the biomass of six dominant species at Silverbell was estimated. The total biomass of the workers is 586 g, equivalent to 3696 kcal/ha for 1,600,000 workers. The biomass is about 105 g for *Veromessor pergandei*, 1 g for *Pheidole xerophila tucsonica*, 159 g for *Novomessor cockerelli*, and 305 g for *Pogonomyrmex rugosus*.

126. Germano, David J.; Hungerford, C. Roger. 1981. Reptile population changes with mnipulation of Sonoran Desert shrub. Great Basin Naturalist. 41(1): 129-138.

The diversity and abundance of reptiles were studied in three vegetation types on the Santa Rita Experimental Range, Arizona. Total reptile sightings were greatest in undisturbed mesquite and mesquite with irregularly shaped clearings. No zebra-tailed lizards (*Callisaurus draconoides*) or desert spiny lizards (*Sceloporus magister*) were seen, and significantly fewer western whiptails (*Cnemidophorus tigris*) were in the mesquite-free area. Only the Sonora spotted whiptail (*Cnemidophorus sonorae*) was significantly more abundant in the mesquite-free area than in the undisturbed mesquite. In an effort to increase grass production for cattle in mesquite grasslands, it is preferable to clear irregularly shaped areas rather than to attempt total mesquite removal if reptiles are to be considered.

127. Germano, David Joseph. 1978. Responses of selected wildlife to mesquite removal in desert grassland. Tucson, AZ: University of Arizona. 60 pp. M.S. thesis.

Mesquite with clearings contained significantly more black-tailed jackrabbits, antelope jackrabbits, Gambel's quail, western whiptails, and all reptiles sighted than mesquite-free areas.

128. Gilbert, Denis Peter. 1980. Deterministic model of soil moisture to predict forage yield on semiarid rangelands. Tucson, AZ: University of Arizona. 97 p. M.S. thesis.

The model is a continuous, deterministic computer simulation that predicts the soil moisture regime of the soil profile. This in turn is used to calculate a stress index value. Annual forage yield is then estimated as a function of stress index values. Field tests between actual data and simulated yield data resulted in .1 kg/hectare average annual difference.

129. Giner-Mendoza, Mateo. 1986. Effect of clipping on photosynthesis, respiration and production of *Eragrostis lehmanniana* Nees and *Digitaria Californica* (Benth.) Henr. Tucson, AZ: University of Arizona. 54 p. M.S. thesis.

Arizona cottontop (*Digitaria californica* (Benthe.) Henr.) has been replaced by lehmann lovegrass (*Eragrostis lehmanniana* Nees) on southeastern Arizona rangelands. This research was conducted to investigate the effects of defoliation on their physiological and morphological characteristics. Plants were defoliated by clipping at a 5-cm height and measurements made every 14 days. Clipping did not affect apparent photosynthesis or dark respiration during the 56-day study; however, defoliation reduced above-ground biomass and the nitrogen and phosphorus content in both species. Root biomass of clipped Arizona cottontop and lehmann lovegrass declined 50% and 28%, respectively. Nitrogen and phosphorous concentrations in Arizona cottontop roots declined 42% and 61%, and 32% and 27% in lehmann lovegrass, respectively. The small decline in lehmann lovegrass root production and the major change in Arizona cottontop root biomass after defoliation may partially explain why lehmann lovegrass has been replacing Arizona cottontop.

130. **Glendening, George E. 1937a. Improving depleted ranges through artificial revegetation. Western Livestock Journal. November: 3.**

Broadcast seeding of native forage grasses followed by light harrowing to cover the seed is practical on small areas where the top soil is still in place. Maintenance of sufficient litter cover is an essential objective in proper range management. Light grazing is needed until plants become properly established.

131. **Glendening, George E. 1937b. Litter aids germination of grass seeds and establishment of seedlings. Research Note 7. Tucson, AZ: U.S. Department of Agriculture, Forest Service, Southwestern Forest and Range Experiment Station. 2 p.**

Tests were conducted to determine the effects of litter on the germination of grass seeds and survival of seedlings. Preliminary observation showed grasses fail to germinate on bare ground, despite an abundance of seed. Excellent stands of seedlings covered area mulched with barley straw.

132. **Glendening, George E. 1937c. A method of revegetating small key plots on eroded areas. Research Note 8. Tucson, AZ: U.S. Department of Agriculture, Forest Service, Southwestern Forest and Range Experiment Station. 2 p.**

Topsoil material obtained from grassy areas was spread to a depth of about 3 inches on four small plots in a denuded area. One and a half years later, plots were covered with seedlings of annuals and perennial grasses.

133. **Glendening, George E. 1937d. Reseeding on denuded "adobe flats." Research Note 19. Tucson, AZ: U.S. Department of Agriculture, Forest Service, Southwestern Forest and Range Experiment Station. 2 p.**

Preliminary observations revealed greater seedling germination and establishment on disked and mulched plots than on disked-only plots.

134. **Glendening, George E. 1938. The place of tanglehead in artificial revegetation. Research Note 37. Tucson, AZ: U.S. Department of Agriculture, Forest Service, Southwestern Forest and Range Experiment Station. 2 p.**

Germination tests indicate the seed is better than 50% viable. Seed will germinate under extremely adverse moisture and soil conditions; and the seedlings, once started, are especially drought tolerant. Seed dispersal is good. Tanglehead thrives best at altitudes of 4,000 to 5,000 feet but grows well as low as 2,500 feet.

135. **Glendening, George E. 1939a. Comparison of the effects of various kinds of artificial litter upon the germination of grass seeds. Research Note 61. Tucson, AZ: U.S. Department of Agriculture, Forest Service, Southwestern Forest and Range Experiment Station. 4 p.**

The germination of grass seeds on deteriorated barren soils can be greatly increased through the application of artificial litter in the form of straw or hay. The establishment of seedlings of important forage grasses was practically prohibited where some form of litter was lacking.

136. **Glendening, George E. 1939b. The development of tanglehead (*Heteropogon contortus*) grass seedlings as related to soil moisture and competition. Tucson, AZ: University of Arizona. 33 p. M.S. thesis.**

The study determined the effect of different frequencies of irrigation and varying intensities of competition for light and soil moisture upon the development of shoots and roots, storage of starch, and recovery after drought of tanglehead seedlings. Maximum development of shoots and roots occurred under most frequent irrigation and least intense competition, whereas shoot/root ratios were found to be inversely proportional to these two factors. Amount of starch storage showed no consistent relation to treatments. Soil moisture was attributed to be the major controlling factor in development of plants.

137. **Glendening, George E. 1939c. How to establish black grama on depleted semidesert ranges. Research Note 52. Tucson, AZ: U.S. Department of Agriculture, Forest Service, Southwestern Forest and Range Experiment Station. 4 p.**

Tests showed reasonably good success in establishing grass clumps by transplanting during the rainy season. Protection from grazing enhances chances for establishment. Planting requirements are discussed.

138. **Glendening, George E. 1939d. The place of tanglehead in artificial revegetation. Arizona Stockman. February: 6, 18.**

Germination tests indicate the seed is better than 50% viable. Seed will germinate under extremely adverse conditions. Planting suggestions are proposed.

139. **Glendening, George E. 1941. Development of seedlings of *Heteropogon contortus* as related to soil moisture and competition. Botanical Gazette. 102(4): 684-698.**

Based on dry weight, maximum development of shoots and roots of tanglehead grass seedlings occurred under most frequent irrigation and least intense competition. Shoot/root ratios were greatest under most frequent watering and most intense competition. Lack of moisture at the soil surface retarded the initiation of adventitious roots under field and greenhouse conditions. Tillering was closely associated with the establishment of the adventitious root system. Soil moisture had a greater effect upon the plants than competition and appears to be the major controlling factor under range conditions.

Rapid resumption of growth after drought periods of 3 and 8 weeks, during which soil moisture was below the wilting coefficient, indicates the inherent drought- resistance of these seedlings.

140. Glendening, George E. 1942. Germination and emergence of some native grasses in relation to litter cover and soil moisture. Journal of the American Society of Agronomy. 34(9): 797-804.

Results showed that moisture content at all levels was consistently greater under straw and gauze than on bare ground, and that the length of time during which moisture content of the surface soil was above the calculated water content was greatest under the straw litter. Germination and emergence of grass seedlings was increased from 4 to more than 20 times over that on the bare ground by the various surface-soil treatments.

141. Glendening, George E. 1949a. Cactus--curse or blessing? Arizona Farmer. 38(17): 26, 27.

The merits and disadvantages of cholla and prickly pear on Arizona ranges are discussed, based on work from SRER.

142. Glendening, George E. 1949b. Some probable future developments in control of noxious range plants. Journal of Range Management. 2: 149-152.

This study reports on research needs related to controlling noxious plants, chemicals and their application, mechanical equipment, and biological control.

143. Glendening, George E. 1950a. Harmful range plants--what can be done about them? Arizona Stockman. 16(9): 19, 60, 61.

Various methods of control are discussed with reference to SRER.

144. Glendening, George E. 1950b. Noxious tree and shrub invasion and control in Arizona. Arizona Cattlelog. 6(2): 18-21.

Problems associated with the invasion of mesquite, juniper, burroweed, snakeweed, and cactus are highlighted. Effective control methods are suggested for use.

145. Glendening, George E. 1952a. A round-up of shrub control studies in the southwest. Arizona Cattlelog. 7(12): 5-12.

The author discusses current research, suggests places where additional studies are most critically needed, and suggests state-of-the-art of control methods.

146. Glendening, George E. 1952b. Some quantitative data on the increase of mesquite and cactus on a desert grassland range in southern Arizona. Ecology. 33(3): 319-328.

Results show that mesquite more than doubled in number and crown area while perennial grass density decreased more than 95% under all grazing treatments. Mesquite may attain a crown canopy cover of about 30% on site.

147. Glendening, George E. 1953. Noxious plant control on Arizona rangelands. Arizona Cattlelog. July: 25-29.

The problem of noxious plants on rangelands are discussed with particular references to research work done on the SRER.

148. Glendening, George, E.; Paulsen, Harold A. Jr. 1950. Recovery and viability of mesquite seed fed to sheep receiving 2, 4-D in drinking water. Botanical Gazette. 3: 486-491.

Some seeds required 8 days to pass through the alimentary tract of sheep. Greater than 27% of mesquite seeds were found to be immediately or potentially viable after passage.

149. Glendening, George E.; Paulsen, Harold A. Jr. 1955. Reproduction and establishment of velvet mesquite as related to invasion of semidesert grasslands. Technical Bulletin 1127. Washington, DC: U.S. Department of Agriculture, Forest Service. 50 p.

A comprehensive bulletin on the ecology of mesquite and its relation to range management. Important characteristics of mesquite that favor initial establishment are discussed. Experimental evidence showed that competition by native perennial grasses markedly reduced seedling establishment. Grazing practices, which allow maximum development of grass stands and minimize seed dissemination, may be expected to reduce the rate of spread of mesquite into uninfested grassland. In controlled burn tests, young seedlings were found to be killed during late spring.

150. Gomes, Hilton de Souza. 1983. Forage preference and grazing behavior of Hereford and Barzona cattle on southern Arizona range. Tucson, AZ: University of Arizona. 52 p. M.S. thesis.

A study was conducted to compare diets selected by Hereford and Barzona cows and study their summer behavioral activities. Diet was determined by microhistological analysis of fecal samples. No practical differences in diet between breeds was detected. Grazing behavior was similar for both breeds, with grazing and ruminating constituting around 80% of daily activities.

151. Gorsuch, David M. 1934. Life history of the Gambel quail in Arizona. Biological Science Bulletin No. 2. Tucson, AZ: University of Arizona. 89 p.

Gambel quail outranked other game species in importance. Coveys formed large flocks during winter months in response to food plants. Mating began with formation of winter flocks. The nesting season normally extends from April 1 to September 1. Quail rarely bring off two broods per year. Incubation was not commonly shared by the cock. Food was an important factor determining Gambel quail distribution, but water was not necessary for existence. Daily range of a covey extended less than 500 yards. Overgrazing by stock destroyed many quail habitats. Low soil temperatures adversely influenced hatching of eggs.

152. Green, Christine R.; Martin, S. Clark. 1967. An evaluation of precipitation, vegetation and related factors on the Santa Rita Experimental Range. Meteorology and Climatology of Arid Regions Technical Report 17. Tucson, AZ: Institute of Atmospheric Physics, University of Arizona. 82 p.

Monthly and annual precipitation data for 45 rain gages over the SRER are presented. A common 26-year period for 22 of the gages is used in statistical analyses. The results are tabulated and presented graphically. The effectiveness of precipitation on vegetation and soil moisture in the area is discussed. Tables and graphs depict the typical effects to be found within SRER.

153. Greene, Robert A.; Murphy, Guy H. 1932. The influence of two burrowing rodents, *Dipodomys spectabilis spectabilis* (Kangaroo rat) and *Neotoma albigula albigula* (pack rat), on desert soils in Arizona, II--physical effects. Ecology. 13(4): 359-363.

The pack rat produced only slight physical changes in the soil. The burrows of the Kangaroo rat were characterized by increased values for moisture equivalent and water holding capacity of the surface soil, and by the larger percentage of finer sized soil particles. This "mixing" effect is very pronounced in soil having a heavy subsoil, and significant changes may be produced in the texture of the soil.

154. Greene, Robert A.; Reynard, Charles. 1932. The influence of two burrowing rodents, *Dipodomys spectabilis spectabilis* (Kangaroo rat) and *Neotoma albigula albigula* (pack rat) on desert soils in Arizona. Ecology. 13(1): 73-80.

Soil from the dens contained a larger quantity of soluble salts. These increases were especially pronounced in the case of calcium, magnesium, bicarbonate, and nitrate ions. The relation of these animals to soil fertility has been discussed and the conclusions are that, in the long run, the beneficial effects would overshadow the ill effects, and that these animals exert measurable influences upon the chemical and physical properties of the soil. The relation of the amount of vegetation consumed by these animals to the increase they cause through increased soil fertility has not been determined.

155. Griffiths, David. 1901. Range improvement in Arizona. Bureau of Plant Industry Bulletin No. 4. Washington, DC: U.S. Department of Agriculture. 31 p.

The report outlines range research undertaken on SRER. A description of existing range conditions and status of forage production is presented. Important range plants are identified.

156. Griffiths, David. 1904. Range investigations in Arizona. Bureau of Plant Industry Bulletin No. 67 (10 plates). Washington, DC: U.S. Department of Agriculture. 62 p.

The report includes a general study of range problems in southern Arizona based on investigations conducted on SRER and at the Agriculture Experiment Station of Arizona at Tucson. Particular attention is called to carrying capacities and forage production.

157. Griffiths, David. 1910. A protected stock range in Arizona. Bulletin 177. Washington, DC: U.S. Department of Agriculture. 28 p.

Lands under consideration appeared to regain their original productivity after approximately 3 years of complete protection. Evidence thus far secured indicated the best lands would improve under stocking at the rate of one bovine animal to 20 acres. Poorer lands required a correspondingly larger acreage for each animal. Areas with current stocking capacity of one head to 20 acres are very limited. Brush and timber encroach upon grasslands, possibly because of protection from fires. Ground cover was not a factor below an altitude of about 3,500 feet. Although the maximum yield of forage may be reached within 3 years of protection, improvements in quality of forage would probably go on longer through continued supplanting of annual plants by perennials of greater value. Results were secured more rapidly by proper protection from overgrazing than by any other method.

158. Haile, Astatke. 1981. Dynamics of aboveground net primary production in a desert grassland of Arizona. Tucson, AZ: School of Renewable Natural Resources, University of Arizona. 84 p. Ph.D. dissertation.

The mean rate of transfer of biomass from live herbage to standing recent dead herbage was 0.21% per day for 203 days. A rate of transfer of 0.53% per day of live herbage to standing dead for 109 days for perennial grasses during early vegetative growth. Heavy precipitation accelerated growth of live herbage and accounted for losses of standing recent dead and standing old dead herbage to the surface litter component. Summation of growth increments by sample periods provided the highest estimate of aboveground net primary productivity.

159. Hamilton, Louis P. 1942. Observations on the survival of native and exotic plant species in range trial practices in southern Arizona. Tucson, AZ: University of Arizona. 56 p. M.S. thesis.

A description of promising native and exotic species and their performance in the nursery and trial range plantings is given. Species are listed according to the type of site that is to be planted. Reseeding without any seedbed preparation is discouraged.

160. Haskell, Horace S.; Reynolds, Hudson G. 1947. Growth, developmental food requirements and breeding activity of the California jackrabbit. Journal of Mammalogy. 28(2): 129-136.

The ear and hind foot of these animals reached maturity at 15 weeks, total length at 28 weeks, and weight at 32 weeks. Ear length was the only measurement that differed perceptibly between sexes and was greater in males. Forage consumption showed a curvilinear relationship to age from 3 to 28 weeks, after which an average constant amount equivalent to 0.27 pounds of air-dry native forage was consumed. Females born early in one breeding season, although maturing before the end of the breeding season, did not produce young until the following year. The average gestation period in captivity was 43 (41-47) days. Active breeding apparently occurs throughout normal life, since some captive animals were still actively breeding when released at an age of 7 years. The maximum breeding potential for these rabbits was calculated to average 13 to 14 young per female per year.

161. Haverty, Michael I.; Nutting, William L.; LaFage, Jeffery P. 1975. Density of colonies and spatial distribution of foraging territories of the desert subterranean termite, *Heterotermes aureus* (Snyder). Environmental Entomology. 4(1): 105-109.

Density of colonies together with size and spatial distribution of foraging territories of the subterranean termite, *Heterotermes aureus* (Snyder), were determined on a 1600-m^2 bait sampling grid. Bait units (toilet paper rolls) attacked in the first week of the 52-week study and those with large, mean weekly forager counts were considered as colony foci. Lateral spread of colony boundaries was followed weekly. After one year *Heterotermes aureus* had attacked 22.8% of the bait units. Colony density was estimated at 190.4 per ha, mean territory contained 12.5 m^2 and mean number of individuals per colony was speculated to be 22,632.

162. Haverty, Michael Irvin. 1974. The significance of the subterranean termite, *Heterotermes aureus* (Snyder), as a detritivore in a desert grassland ecosystem. Tucson, AZ: Department of Entomology, University of Arizona. 104 p. Ph.D. dissertation.

Wood consumption by *Heterotermes aureus* was best described as a linear or quadratic function relative to temperature. *H. aureus* is a general feeder preferring cholla, mesquite, and catclaw. Surface foraging occurred yearlong between 7°C and 47°C. Increased soil moisture increased foraging intensity. Total density of *H. aureus* was estimated at 431 to 786 per m2, with an average colony size from 23,754 to 49,125.

163. Hawkinson, Richard O. 1968. Cover, soil, and microrelief characteristics which influence runoff on a desert grassland range. Tucson, AZ: University of Arizona. 91 p. M.S. thesis.

Clipping and fertilizer treatments had no significant effect on runoff. Total overstory cover and herbage yield were the only two factors affected significantly by treatments. Percentage of sand, depth of the A horizon, total overstory cover, and litter accounted for most variation in runoff.

164. Hayer, William T., III. 1963. Seasonal influences on the grazing ruminant's diet and rumen function. Tucson, AZ: University of Arizona. 35 p. M.S. thesis.

Although there was a high correlation (.84) between rumen evacuation samples and hand-clipped samples, steers selected forage in all instances higher in crude protein than that of hand-clipped samples. Average crude protein content of two main grasses was 5.75% compared to 10.95% crude protein for rumen evacuation samples. Greatest variations in protein occurred during seasons of good moisture. There were no marked changes in ratios of volatile fatty acid fractions.

165. Heede, Burchard H. 1981. Gully control by check dams. Part Five: Field demonstration - Santa Rita Experimental Range, Arizona. University of Arizona and U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo. [Audio-video cassette, 48 minutes, produced cooperatively by the University of Arizona and U.S. Department of Agriculture, Forest Service. Available from University of Arizona.]

A gully was the object of a field seminar for students of the School of Renewable Natural Resources, University of Arizona. The video demonstrates basic principles in gully control by check dams, valid regardless of size of gully or physiographic region. The proposed treatment is hypothetical--structures are not installed.

166. Hendricks, Barnard A. 1936. Vine-mesquite for erosion control on southwestern ranges. Leaflet 114. Washington, DC: U.S. Department of Agriculture. 8 p.

Grasses are the most effective plants for protecting the ground surface from soil-erosion forces on open ranges, as well as in glades and valleys; and grasses constitute the principal part of the vegetation on rangelands where gullying and other forms of soil erosion have been brought under control through natural revegetation. Vine-mesquite

(*Panicum obtusum*) may be regarded as one of the best native southwestern grasses for use in revegetating deteriorated range lands and in controlling soil erosion. It forms a good protective ground cover in and along drainage depressions, thus indicating its suitability for such use.

167. Hinds, David Stewart. 1970. A comparative study of thermoregulation and water balance in hares and rabbits of the Sonoran desert. Tucson, AZ: Department of Biological Sciences, University of Arizona. 145 p. Ph.D. dissertation.

During the winter, metabolism was higher than the summer rate above thermoneutrality for *Syvilagus auduboni* and *Lepus alleni*, and decreased at ambient temperatures below thermoneutrality for *S. audoboni* and *L. Californicus*. Water loss during the winter was lower than the summer values at ambient temperatures below 25°C and higher above. Body temperature in general did not differ seasonally below 25°C. Differences in patterns of acclimatization were correlated with relative size, geographical distribution, and microhabitat selection of species.

168. Holt, Garry A. 1959. The effect of commercial fertilizers on forage production on a desert grassland site. Tucson, AZ: University of Arizona. 29 p. M.S. thesis.

Ammonium phosphate and ammonium nitrate were applied in pellet form at rates of 25, 50, and 100 pounds of nitrogen per acre. Fertilized plots showed a highly significant increase in total forage produced over unfertilized plots at all rates of application. Yields from ammonium phosphate application appeared to exceed those obtained from ammonium nitrate at all rates. Plots fertilized with ammonium phosphate showed a linear response in forage production, while plots fertilized with ammonium nitrate reached a point of diminishing return near the 100 pound application rate.

169. Holt, Garry A.; Wilson, David G. 1961. The effect of commercial fertilizers on forage production and utilization on a desert grassland site. Journal of Range Management. 14(5): 252-256.

A marked response was obtained for all rates of application of ammonium phosphate and ammonium nitrate. Forage production was almost doubled, even at lowest rates. Cattle utilization was three, four and five times as great as on check plots. The green feed period was extended up to 6 weeks.

170. Huckell, Bruce B. 1984. The archaic occupation of the Rosemont area, Northern Santa Rita Mountains, Southeastern Arizona. University of Arizona Archeological Series No. 147(1): 1-297.

Selected sites of the northern extension of the range are described in terms of the archeological findings of prehistoric occupation by Indians.

171. Hull, Herbert M. 1956. Studies on herbicidal absorption and translocation in velvet mesquite seedlings. Weeds. 4(1): 22-42.

The use of a nontoxic oil in a 1:4 oil-water emulsion as a carrier for 2,4,5-T resulted in greater injury to the nontreated distal foliage than did diesel oil, and had a greater tendency to be translocated to more distant portions of the plant than did ester formulations. Type and concentration of emulsifying agent was found to be of particular importance for maximum absorption of herbicide.

172. Hull, Herbert M. 1958. The effect of day and night temperatures on growth, foliar wax content, and cuticle development of velvet mesquite. Weeds. 6(2): 133-142.

Total wax content of the leaflets was highest in plants grown at the higher temperatures both day and night. Content of nonwax fatty substances was highest in plants grown at lower night temperatures. Melting point of the wax was directly correlated with both day and night temperatures, whereas the iodine number was influenced predominantly by night temperatures. Highest iodine numbers were found at the extremes of night temperatures, with medium night temperatures resulting in lower values.

173. Humphrey, R. R. 1938. Burroweed in relation to grass cover and grazing. Arizona Stockman. March: 12, 14.

Soil erosion seemed to be an important factor in the spreading of burroweed. In the absence of much sheet erosion, total protection from grazing afforded some control of burroweed. Best results may be obtained when areas are protected from livestock grazing for 10 to 14 years.

174. Humphrey, R. R. 1952. Climatic change in Arizona. Arizona Cattlelog. April: 60-62.

The author examines reasons for changes in natural vegetation.

175. Humphrey, R. R. 1953. The desert grassland, past and present. Journal of Range Management. 6(3): 159-164.

A historical and vegetational study of data led to the conclusion that the desert grassland of southwestern U.S. and Mexico is not a true climax, but is a subclimax maintained by fire. The true climax of low trees, brush, and cacti, with an understory of grasses and low-growing shrubs, developed extensively on areas that were once grasslands.

176. Humphrey, R. R.; Mehrhoff, L.A. 1958. Vegetation changes on a southern Arizona grassland range. Ecology. 39(4): 720-726.

Vegetation surveys over a 50-year period were analyzed to determine changes in area and abundance of the four most common woody plants: creosotebush, burroweed, cholla, and mesquite. All of the species increased markedly in area and abundance. Climate, grazing rodents and fire were evaluated as factors that may have contributed to the vegetational changes noted. Conclusions were: (1) there have been no apparent changes in climate that would result in the vegetational changes noted; (2) grazing by domestic livestock has affected the composition of the vegetation, in part because of seed dissemination, in part because of selective grazing, and in part because of the removal by grazing of grass that formerly served as fuel for range fires; (3) rodents bury mesquite seeds and transport cholla cactus joints, thus serving to propagate those plants; (4) fires maintained the desert grassland as such, prior to the introduction of livestock; and (5) shrub invasion of southern Arizona semidesert grassland ranges is due primarily to reduction of range fires.

177. Humphrey, Robert R. 1936a. Growth habits of barrel cacti. Madrono. 3(8): 348-352.

A brief description is given of the morphology, habitats, distribution, establishment, and general habits of barrel cacti. Seedlings of the barrel cactus commonly become established in the shade cast by other vegetation. As seedlings grow, they exhibit a tendency to lean toward the most intense light available, often resulting in their uprooting and death.

178. Humphrey, Robert R. 1936b. Notes on altitudinal distribution of rattlesnakes. Ecology. 17(2): 328-329.

Members of *Crotalus atrox, C. molossus, and C. scutulatus* seem to occupy rather definite zones in a given locality, whereas *C. tigris* was observed to have a wider distribution.

179. Humphrey, Robert R. 1937. Ecology of the burroweed. Ecology. 18(1): 1-9.

A treatise dealing with the ecology of *Aplopappus fruticosus* is provided, with particular emphasis on establishment and local distribution.

180. Humphrey, Robert R. 1959. Lehmann's lovegrass, pros and cons. *In:* Your range--its management. Report No. 2. Tucson, AZ: University of Arizona, Agricultural Experiment Station: 28 p.

Two chief advantages of lehmann lovegrass are its ability to establish easily and that it provides green feed in the winter and spring when most of the native grasses are largely dormant. Its disadvantages include low forage value and its highly competitive nature with native species.

181. Hungerford, Charles R. 1960a. Adaptations shown in selection of food by Gambel quail. Condor. 64(3): 213-219.

Although largely graminiferous, quail had a variable seasonal diet and sufficient succulent foods are taken to maintain body moisture. Food preference should be considered in quail management, in evaluating range quality, and in locating watering devices.

182. Hungerford, Charles R. 1960b. Water requirements of Gambel's quail. Transactions North American Wildlife and Natural Resources Conference. 25: 231-240.

Quail showed a dependence on moist succulent plant foods and exhibited good survival and reproduction from such foods. Quail can and do subsist well without free water and catchments are considered nonessential.

183. Hungerford, Charles R. 1964. Vitamin A and productivity in Gambel's quail. Journal of Wildlife Management. 28(1): 141-147.

The influence of available natural sources of vitamin A on reproduction of Gambel's quail (*Lophortyx gambelii*) in southeastern Arizona was investigated in a 5-year study. Birds were observed and collected during critical seasons on basic types of quail range. The amount of liver vitamin A in a sample of 177 birds was found to vary with rainfall and the resulting green plant growth. Differences in covey behavior, reproductive activity, and a size variation in reproductive organs was associated with differences in vitamin A storage. Vitamin A, or a closely associated substance derived from green plant material, apparently acts as a stimulator that influences the rate of breeding in this desert quail.

184. Hungerford, Charles Roger. 1960. The factors affecting the breeding of Gambel's quail *Lophortyx gambelii gambelii* in Arizona. Tucson, AZ: Department of Watershed Management, University of Arizona. 94 p. Ph.D. dissertation.

Rate of breeding was governed by the amount of late-winter and spring rainfall and production of green plants. Green plant food stimulated development of the reproductive organs of both sexes and egg production, and increased hatchability of the eggs and survival of the young. The stimulating factor derived from green plants was either carotene or an accompanying substance similarly assimilated, stored, and depleted. Birds needed a liver storage of converted vitamin A at a level above 175 mcg. The yearly production of young quail was the most important factor controlling their numbers.

185. Johnson, Vard H. 1941. The geology of the Helvetia Mining District Arizona. Tucson, AZ: Department of Geology, University of Arizona. 113 p. Ph.D. dissertation.

This study discusses the stratigraphy of the area, with special emphasis on sedimentary formations, igneous rocks, metamorphism, economic geology, minerals and mining history. Laboratory studies included 32 thin sections from the igneous and metamorphic rocks, 20 polished sections of the ore-bearing rocks, and an interpretation of paragenetic relations of the minerals of these sections.

186. Joy, R. J.; Slayback, Robert D.; Renney, Clinton W. 1972. Palar--a new lovegrass for the southwest. Progressive Agriculture in Arizona. 25(5): 4-5.

The performance of Palar, commercial Wilman, Catalina, and lehmann lovegrasses are compared.

187. Judd, B. Ara. 1937. *Aplopappus fruticosus* or burroweed. Journal of the American Society of Agronomy. 29(4): 332-334.

Burning of burroweed on protected vs. grazed plots showed a slightly greater increase in stem numbers and height growth on the protected area.

188. Kincaid, D. R.; Holt, G. A.; Dalton, P. D.; Tixier, J. S. 1959. The spread of Lehmann lovegrass as affected by mesquite and native perennial grasses. Ecology. 40(4): 738-742.

Mesquite densities of 25 trees per acre or less significantly reduced lehmann lovegrass establishment. Native grass density was affected adversely by even a few mesquite trees. Native grass density increased up to 75% where mesquite had been reduced from a dense stand to 25 trees per acre, and it was approximately twice as great in the plot with no mesquite as in the plot with 25 trees per acre. Although removal of mesquite released the native grasses, seeding lehmann lovegrass served only to reintroduce competition from another source. As the lovegrass spread from the seeded strip into the area, it reduced and eventually largely replaced the native grasses. Reseeding an area cleared of mesquite with lovegrass appeared to be of little or no value if remnants of native perennial grasses were present.

189. Klemmedson, J. O.; Barth, R. C. 1975. Distribution and balance of biomass and nutrients in desert shrub ecosystems. US/ICP Desert Biome Research Memorandum 75-5. Logan, UT: Ecology Center, Utah State University. 18 p.

Over 77% of ecosystem nitrogen was found in the soil; 20% was in shrub biomass; the remainder was in understory vegetation and litter. Carbon was almost equally distributed between soil and biomass. Total ecosystem nitrogen averaged 319 g/m^2 and carbon averaged 4.5 kg/m^2. Paloverde and mesquite shrubs form a center from which properties change in a more or less consistent manner with distance, depending on the ecosystem component. From shrub center to beyond the canopy edge, soil nitrogen declined by 50% at the surface and by lesser amounts with depth. Carbon displayed similar trends. Standing understory vegetation and shrub litter for both shrub species decreased as distance from the center of shrubs increased. Vertical gradients for soil carbon and nitrogen were abrupt with little change below the 5- to 15-cm layer.

190. Klemmedson, James O. 1974. Distribution and balance of biomass and nutrients in desert shrub ecosystems. US/ICP Desert Biome Research Memorandum 74-6. Logan, UT: Ecology Center, Utah State University. 6 p.

Previously observed patterns of seasonal change in percentage of nitrogen in annual plant parts of two varieties of mesquite (*Prosopis juliflora* var. *glandulosa* and *P. juliflora* var. *velutina)* were strongly manifested, perhaps because of heavy fall and winter moisture. Although percentage nitrogen in mulch of the overstory species appeared not to vary spatially under the shrub, nitrogen percentage of understory mulch and the absolute amount of nitrogen in mulch of both overstory and understory species did not appear to vary spatially. This was reflected in strong spatial distribution patterns for soil nitrogen and, in turn, phytomass and amount of nitrogen in standing live and dead understory vegetation.

Soil under mesquite (*P. juliflora*var. *glandulosa*) sampled at the Jornada Experimental Range was higher in percentage nitrogen in the surface 5 cm and in the amount of nitrogen in the 0-60 cm depth than soil under mesquite (var. *velutina*) at Santa Rita. The influence of variety *glandulosa* at Jornada on nitrogen status of the soil appeared large in terms of the phytomass of the shrubs, but of about the same magnitude as variety *velutina* at Santa Rita in terms of nitrogen status of soil beyond the shrub canopies.

191. Klemmedson, James O.; Smith, Edwin L. 1972. Distribution and balance of biomass and nutrient in desert shrub ecosystems. US/IBP Desert Biome Research Memorandum 72-14. Logan, UT: Ecology Center, Utah State University. 8 p.

Nitrogen content of plant parts varied widely and may have been a function of phenology in some plant parts. Carbon content was relatively constant. Percentage distribution of these nutrients varied widely over the entire age class distribution of trees but appeared relatively constant between trees that are over 2.5 m in canopy diameter. Initial data suggested meaningful spatial and temporal differences in weight and nutrient content of mesquite mulch.

192. Klemmedson, James O.; Smith, Edwin L. 1973. Biomass and nutrients in desert shrub ecosystems. US/IBP Desert Biome Research Memorandum 73-8. Logan, UT: Ecology Center, Utah State University. 9 p.

Seasonal patterns of change in percentage of nitrogen in leaves of mesquite and palo verde were observed and appear real. Nitrogen content of mulch of the overstory shrub appeared not to vary spatially under the shrub, but that of understory species did. The understory species may have been acting as a bioassay of variable soil N content with distance away from the stem of the shrub. Although 11% of N in the aboveground phytomass of mesquite was contained in the annual plant parts and was subject to seasonal variation, N in the aboveground portion of mesquite was highly correlated with phytomass.

193. Knipe, Theodore. 1957. Javelina in Arizona. Wildlife Bulletin No. 2. Phoenix, AZ: Arizona Game and Fish Department. 96 p.

Javelina ran in herds of 8 to 9, with winter herds being larger. Their sense of smell is very keen, their hearing and eyesight inferior. There are no seasonal migrations and cruising radius is less than 3 miles. Extensive life history notes are presented. The major year-round range is the upper bajada country of coarse-textured, well-drained soils and foothill range of mountain slopes.

194. LaFage, J. P.; Haverty, M. I.; Nutting, W. L. 1976. Environmental factors correlated with the foraging behavior of a desert subterranean termite, *Gnathamitermes perplexus* (Banks). Sociobiology. 2(2): 155-169.

Maximum foraging density and dry-weight biomass were estimated at 705,200 foragers/ha and 451.2 g/ha. Foraging activity was limited by upper level (0-15 cm) soil temperatures within the range of 9 to 49°C. Periodic rises in soil moisture resulting from rainfall increased foraging intensity. *G. perplexus* foraged at nearly 100% of the toilet paper rolls on the study site. The number of foragers observed at the surface at a given point in time can be expressed by the equation, in Y = 2.39 + 0.31 T - 0.11 R - 0.01 T2 + 0.54 1n R, where Y = the number of termites at 100 rolls of toilet paper, T = the daily mean temperature at the roll-soil interface, and R = daily rainfall.

195. LaFage, Jeffery P.; Nutting, William L.; Haverty, Michael I. 1973. Desert subterranean termites: A method for studying foraging behavior. Environmental Entomology. 2(5): 954-956.

A modification of the bait-sampling method provided data on the physical factors regulating daily and seasonal foraging behavior in addition to information about spatial distribution of surface foraging groups.

196. LaFage, Jeffery Paul. 1974. Environmental factors controlling the foraging behavior of a desert subterranean termite, *Gnathamitermes perplexus* (Banks). Tucson, AZ: University of Arizona. 41 p. M.S. thesis.

Maximum foraging density and dry-weight biomass were estimated at 705,000 foragers/ha and 451.2 g/ha, respectively. Foraging activity was limited by upper soil (0-15 cm) temperatures within the range of 9 to 49°C. Periodic rises in soil moisture resulting from rainfall modified foraging intensity. An equation is given to determine the number of foragers observed at the surface at a given point in time.

197. Lane, L. J.; Diskin, M. H.; Wallace, D. E.; Dixon, R. M. 1978. Partial area response on small semiarid watersheds. American Water Resources Association, Water Resources Bulletin. 14(5): 1143-1158.

Significant errors in estimating surface runoff and erosion rates are possible if a watershed is assumed to contribute runoff uniformly over the entire area, when actually only a portion of the entire area may be contributing. Generation of overland flow on portions of small semiarid watersheds was analyzed by three methods: an average loss rate procedure, a lumped-linear model, and a distributed-nonlinear model. These methods suggested that, on the average, 45, 60, and 50% of the drainage area was contributing runoff at the watershed outlet. Infiltrometer data support the partial area concept and indicate that the low infiltration zones are the runoff source areas as simulated with the distributed-nonlinear model.

198. Lane, L. J.; Morton, H. L.; Knisel, W. G., Jr.; Wallace, D. E. 1978. Distribution of herbicides in soil and runoff on semiarid rangelands. *In:* Abstracts 1978 Meeting. Tucson, AZ: Weed Science Society of America: 39-40.

In studies on semiarid watersheds in Arizona, herbicides were detected in the run-off during the season of application (over a period of 78 days), but not thereafter. Herbicide concentrations in the surface soil (0.1 cm) seemed to follow a first-order decay; but concentrations in run-off samples varied with time in a more complex manner.

199. Lane, L. J.; Morton, H. L.; Wallace, D. E.; Wilson, R. E.; Martin, R. D. 1977. Nonpoint-source pollutants to determine runoff source areas. Hydrology and Water Resources in Arizona and the Southwest. 7: 89-102.

Based on the concept of partial area response, a runoff tracer study was conducted on two small watersheds. The watersheds were partitioned into four geomorphic subzones or hydrologic response units. Each of the four zones on both watersheds was treated with about 1 kg/ha of an individual water soluble herbicide. Runoff volumes and sources estimated using the tracers were consistent with results from simulation studies. Also, the principle of corresponding runoff and pollutant discharge rates was used to develop two methods of runoff hydrograph estimation from each of the geomorphic subzones. Method 1 matched the mean total concentration and total runoff volume. Method 2 matched the instantaneous total concentration and the instantaneous runoff rate from the entire watershed. Results from the two methods suggested that, although they may be equivalent with respect to runoff volume, method 2 may be more consistent with respect to peak discharge.

200. Lane, L. J.; Wallace, D. E. 1976. Simulation of partial area response from a small semiarid watershed. *In:* Hydrology and Water Resources

in Arizona and the Southwest. Proceedings from the 1976 Meeting of American Water Resources Association, Arizona Section. Tucson, AZ: Arizona Academy of Science, Hydrology Section. VI: 137-147.

An attempt is made to improve understanding of how geomorphic features affect hydrologic response, particularly partial area response, on semiarid watersheds. Results from a small watershed in central Arizona relating average percent contributing area with average loss rate suggested a similar relation on the smaller Santa Rita Watershed. This similarity was confirmed by analysis of eight small runoff events.

201. Langley, William. 1980. Habitat preference of *Onychomys torridus (muridae)* in a desert grassland. The Southwestern Naturalist. (25)2: 266-267.

In the desert grasslands of Arizona, southern grasshopper mice preferred habitats with a prevalence of burroweed, a scarcity of perennial grasses, and bare patches of compact soil.

202. Langley, William. 1981. The effect of prey defenses on the attack behavior of the southern grasshopper mouse (*Onychomys torridus*). Journal of Comparative Ethology. 56(2): 115-127.

Grasshopper mice attack crickets, stink beetles, and scorpions differently. To determine what aspects of the attack behavior represent adjustments to each prey's defense, attacks by inexperienced and experienced mice on prey capable or incapable of using its defenses were compared. Each defense caused different changes in the mouse's approach, seizure, and orientation of bites. Learning was responsible for these changes and each of these adjustments specifically counteracted the prey's defenses.

203. Langley, William Michael. 1978. The development of predatory behavior in *Onychomys torridus* (Coves). Tempe, AZ: Department of Zoology, Arizona State University. 170 p. Ph.D. dissertation.

The predatory behavior of grasshopper mice was studied using various combinations of sight, smell, and hearing. Mice relied on hearing in finding moving prey, on olfaction in finding stationary prey, and on vision only to a limited extent. Maturation and experience increased the mouse's efficiency by changing its attack. Experienced mice attacked prey that could use their defenses the same as those that couldn't; inexperienced mice did not.

204. Laubscher, James A. 1968. Chlorinated insecticide residues in the Santa Rita Mountain area. Tucson, AZ: University of Arizona. 43 p. M.S. thesis.

Soil insecticide levels decreased logarithmically with an increase in downwind distance from the application area. In each group of animals studied there was a proportional decrease in insecticide residue levels as soil residue levels decreased. It's possible to demonstrate the levels of a contaminant within other systems.

205. Leopold, Aldo. 1933. Predator control: Chapter X. *In:* Game Management. New York: Charles Scribner's Sons: 232-233.

An example demonstrating Elton's "Pyramid of numbers" concept for Gambel and scaled quail range on SRER is provided.

206. Letey, J., Jr.; Stolzy, L. H.; Mehuys, G. R.; Weeks, L. V. 1973. Evaluation of critical soil properties needed to predict soil water flow under desert conditions. US/IBP Desert Biome Research Memorandum 73-43. Logan, UT: Ecology Center, Utah State University. 12 p.

Hydraulic conductivity and soil-water diffusivity have been measured for a desert soil over a suction range of 0 to -50 bars, using a transient outflow method. Results show good agreement between experimental and calculated conductivity values, except at the higher soil suctions (>6 bars). At these suctions, experimental values appear to be too high. Several reasons for this divergence are given.

207. Lister, P. B. 1938a. How utilization of forage plants varies by seasons on semidesert grasslands. Research Note 40. Tucson, AZ: U.S. Department of Agriculture, Forest Service, Southwestern Forest and Range Experiment Station. 3 p.

Results showed cattle definitely prefer different forage plants at different times of the year. While there is a tendency for variety in the diet, some plants are sought more eagerly than others, and all species are more desirable at some seasons than others.

208. Lister, P. B. 1938b. Seasonal utilization of forage plants. The Cattleman. August 25: 29-30.

A 3-year study found that cattle exhibit preferences for different forages at different times of the year.

209. Lister, P. B. 1939. Forage plant utilization varies by seasons on semi-desert lands. Arizona Stockman. August: 10-11.

Cattle preferred different forage plants at different times of the year. While there is a tendency for variety in diet, some plants are sought more than others, and all species are more desirable at some seasons than others.

210. Lister, Paul B.; Schumacher, Francis X. 1937. The influence of rainfall upon tuft area and height growth of three semidesert range grasses in southern Arizona. Journal of Agricultural Research. 54(2): 109-121.

The effect of variation in precipitation distribution on the annual density change and height growth of three forage grasses was determined by statistical analysis. The method consisted of describing the observed monthly precipitation by orthogonal polynomials of degree 8; the coefficients of

these were then used as independent variables in six multiple-correlation analyses.

Graphic expressions of the average effect of an added inch of precipitation per month indicate that the most beneficial precipitation distribution from normal for both density change and height growth consists of relatively dry winters sandwiched between relatively wet autumns and springs. In general, threeawn grass seems well adapted to such variation in precipitation, including below--normal seasonal precipitation, and even benefits. Adaptations occur as either density change or height growth, although not both at once.

211. Loqa, Harith Jabbouri. 1972. The osmotic values of certain palo verde and saguaro on soil chemical properties. Tucson, AZ: Department of Soils, Water and Engineering, University of Arizona. 128 p. Ph.D. dissertation.

Effects of stemflow, crown drip, leaf litter, bark litter, and grasses under the canopy were investigated on four soils. Chemical analyses revealed order of abundance of Ca, Mg, K, and Na in plants, as well as in soil horizons.

212. Love, L. Dudley. 1934. The osmotic values of certain native forage plants under different climatic and soil conditions in southern Arizona. Tucson, AZ: College of Agriculture, University of Arizona. 72 p. Ph.D. dissertation.

The osmotic values of mesquite, cotton grass, threeawn grass, Rothrock grama, black grama, and spruce-top grama were determined. Plants appeared to carry on their life functions without noticeable stress when soil moisture was less than the wilting coefficient. Some grasses appeared to go through a cycle of growth that is related to their osmotic values.

213. Lovering, T. G.; Cooper, J. R.; Drewes, Harald; Cone, G. C. 1970. Copper in biotite from igneous rocks in southern Arizona as an ore indicator. *In:* Geological Survey Research 1970. Professional Paper No. 700-B. Washington, DC: U.S. Department of the Interior, U.S. Geological Survey: 1-8.

In the Sierrita and Santa Rita Mountains of southern Arizona, rocks from igneous intrusive bodies that are genetically associated with copper deposits contain as much as 0.03% copper; however, biotite separated from these rocks contains as much as 1% copper. Rocks from igneous intrusives in the same area that are not associated with copper deposits contain from a few parts to a few tens of parts per million of copper, and the biotites separated from them contain at most 200 ppm copper. The large composite stock on the east side of the Sierrita Mountains shows a well-defined increase in the copper content of biotite, from a few parts per million in the northern part to as much as 1% near the copper deposits at its southern end. Copper anomalies in biotite in the rocks in this area provide a more sensitive and extensive indication of associated copper mineralization than do those in the whole-rock samples.

214. Martin, Richard Christopher. 1976. Soil moisture use by velvet mesquite (*Prosopis juliflora*). Tucson, AZ: University of Arizona. 33 p. M.S. thesis.

Soil moisture measurements were made using the neutron thermalization method. The mean daily use of soil moisture for an average tree was 468 liters in the summer, 160 liters in the fall, and 644 liters in the spring. Approximate mean daily use for the entire year was 322 liters.

215. Martin, S. C. 1986a. Eighty years of vegetation change on a semidesert range in southern Arizona, U.S.A. and evaluation of causes. *In:* Ross, P. J.; Lynch, P. W.; Williams, O. B., eds. Rangelands: A resource under siege. Proceedings of Second International Rangeland Congress; 1986; Canberra, Australia. Sydney, Australia: Cambridge University Press: 53.

Vegetation changes since 1903 include: fluctuations in *Happlopappus tenuisectus* related to cool-season moisture extremes, 40-year cycles in *Opuntia fulgida* due in part to bacterial activity, continuing increases in *Prosopis glandulosa* var. *velutina* due to influences associated with animal activity and reduced herbaceous cover, and the spread of *Eragrostis lehmanniana*, an exotic.

216. Martin, S. C. 1986b. Integrating fire into rangeland management systems in the southwestern United States. *In:* Ross, P. J.; Lynch, P. W.; Williams, O. B., eds. Rangelands: A resource under siege. Proceedings of Second International Rangeland Congress; 1986; Canberra, Australia. Sydney, Australia: Cambridge University Press: 588.

Fire is useful but not a universally applicable tool for vegetation manipulation on desert and semidesert rangelands. Successful prescribed burning combines adequate knowledge of the ecosystem with proven burning techniques and grazing schedules that provide adequate fuel before the fire and enough rest for recovery of forage plants afterward.

217. Martin, S. Clark. 1943. Grass makes beef. American Hereford Journal. 34(4): 308, 320.

Stocking rates of 30 and 70 acres per cow yielded per-cow beef production figures of 192 pounds and 368 pounds, respectively. The average cow produced 44 pounds more beef for each additional 10 acres of range.

218. Martin, S. Clark. 1944. The buyer pays for beef. American Hereford Journal. 35(10): 40.

The effect of grazing on the range resource is a most significant item in beef production. Properly stocked ranges are capable of yielding more total pounds of beef than heavily stocked ranges.

219. Martin, S. Clark. 1947a. Bet on the rainfall and win. The New Mexico Stockman. 12(4): 76, 78-79. [Also in Arizona Stockman. 12(4): 10-13.]

Rainfall probabilities equal to or exceeding given percentages of the average for the Tucson area are presented. Relationships between rainfall, forage production and stocking rates are discussed.

220. Martin, S. Clark. 1947b. Controlling mesquite with diesel oil. Tucson, AZ: U.S. Department of Agriculture, Forest Service, Southwestern Forest and Range Experiment Station. Research Note 115. 4 p. [Also in The Cattleman. 36(5): 56-56, 59.]

The method described in this paper answers questions related to where, when, why, and how to control mesquite. Specific rules are provided.

221. Martin, S. Clark. 1947c. The effect of mesquite control on the soil moisture content of mesquite-infested range land in southern Arizona. Tucson, AZ: University of Arizona. 36 p. M.S. thesis.

Mesquite roots were most numerous between 6 and 12 inches. The greatest effect of mesquite on the amount and duration of available soil moisture appeared in the 6 to 12 inch depth class while at 12 to 18 inches moisture seldom exceeded the wilting coefficient on either the check or treated areas. The effect of mesquite on soil moisture content was greatest at distances of 10 feet and least at 30 feet from the tree. Mesquite greatly shortens the duration of favorable moisture conditions by causing small reductions in soil moisture content.

222. Martin, S. Clark. 1948a. How long will mesquite beans remain alive in the soil? Cattlelog. 3(7): 25. [Also in Arizona Stockman. 14(3): 34-35; New Mexico Stockman. 13(4): 28-29; The Cattleman. 35(1): 86-87]

The length of time required for water to penetrate the seed coat and the length of time embryos remain alive is provided.

223. Martin, S. Clark. 1948b. Mesquite seeds remain viable after 44 years. Ecology. 29: 393.

Seeds taken from a 1903 herbarium collection germinated 44 years later.

224. Martin, S. Clark. 1957a. Range readiness. Arizona Cattlelog. 13(4): 46-49.

Grazing too heavily or at the wrong time can seriously injure valuable forage plants. Grasses are especially susceptible to grazing damage in the early spring and at the time seed heads are forming. Since occasional grazing at the wrong season is unavoidable, the rancher must offset these periods of improper use by appropriate rest periods. Grazing the same spots and the same plants at the same time every year should be avoided.

225. Martin, S. Clark. 1957b. To control mesquite economically, start early and keep at it. Arizona Cattlelog. 13(6): 22-26.

Although scattered stands of small mesquite are not striking, they are the most economical to control. Early control prevents declines in forage production that will surely come if mesquite is allowed to form dense stands of mature trees.

226. Martin, S. Clark. 1959. To control mesquite economically, start early and keep at it. *In:* Your range--its management. Report No. 2. Tucson, AZ: University of Arizona. Agricultural Experiment Station: 15-16.

Refer to Martin, S.C., 1957b.

227. Martin, S. Clark. 1963. Grow more grass, by controlling mesquite. Progressive Agriculture in Arizona. 15(4): 2.

Perennial grass production was inversely related to density of mesquite on treated areas. Grass yields were several-fold higher on plots with 9 trees per acre as compared to about half as much on plots with 16 to 25 trees per acre.

228. Martin, S. Clark. 1964. Some factors affecting vegetation changes on a semidesert grass-shrub cattle range in Arizona. Tucson, AZ: Department of Watershed Management, University of Arizona. 122 p. Ph.D. dissertation.

Perennial grass yields increased with distance from water, but yields of annual grasses did not. Soils with accumulations of clay in the subsoil supported more perennial grass and less annual grass than soils having sandy or gravelly subsoils. Mesquite was equally abundant on fine and coarse-textured subsoils. Mesquite cover was greater on summer range than on winter or yearlong range. Burroweed was most abundant on summer range at the 1/4 mile distance from water, on the mesquite-free plots, and in the years following a wet spring or wet winter.

229. Martin, S. Clark. 1966a. The Santa Rita Experimental Range. Research Paper RM-22. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 24 p.

Research was begun in 1903 on the Santa Rita, south of Tucson, Arizona, to learn how to attain maximum sustained forage and beef production on semidesert range with reasonable costs. Results reported cover forage production, including dependence on perennial grasses, grazing management, and methods and advantages of controlling mesquite and other desirable plants.

230. Martin, S. Clark. 1966b. Will you see any game today? Progressive Agriculture in Arizona. 18(4): 30-31.

From incidental observations of game birds and animals on SRER, it would not be unusual to walk a day or two without seeing a mule deer or peccary, but two days without seeing a quail or rabbit would be discouraging.

231. **Martin, S. Clark. 1968. Improving semidesert ranges in southern Arizona, U.S.A., by grazing management and shrub control. Annals of Arid Zone. 7(2): 236-242.**

Knowledge gained about semidesert grass-shrub cattle ranges from research on SRER is presented. Perennial grass is the basic crop; therefore, primary attention must be given to the requirements of perennial grasses in designing range management systems. Relatively short-lived shrubs, such as burroweed, invade the range, mature, then decline, depending on weather and other factors; trees, such as mesquite, move in permanently. To produce the best possible crop of forage, we must get rid of the burroweed and mesquite. Productivity of mesquite-infested semidesert ranges can be restored by controlling the mesquite, grazing moderately, and deferring grazing during alternate summers.

232. **Martin, S. Clark. 1970a. Longevity of velvet mesquite in the soil. Journal of Range Management. 23(1)69-70.**

One velvet mesquite seed out of 450 that were buried was sound and germinated after it was dug up 20 years later. The percentage of apparently sound seeds declined fairly rapidly as seeds germinated or decayed (only 10% were sound after 10 years), but viability of the apparently sound seed remained high to the end of the study. Thus, even if no new seed is produced or introduced, some mesquite seedlings may emerge 20 years or more after clearing.

233. **Martin, S. Clark. 1970b. Vegetation changes on semi-desert range during 10 years of summer, winter, and year-long grazing by cattle. Proceedings of the 2nd International Grassland Congress 11: 23-26.**

Perennial grasses fared best under yearlong grazing and least well on winter-grazed range. Perennial grasses did best on ranges where utilization was lightest. Increases in burroweed (*Haplopappus tenuisectus*) were inversely related to perennial grass cover and were greatest under winter grazing.

234. **Martin, S. Clark. 1972. Some effects of continuous grazing on forage production. Arizona Cattlelog. 28(10): 17, 18, 23-25.**

Heavy use affected native grass species composition. Dense grass stands dominated by open-grown plants of bush muhly, slim tridens, and black grama cannot persist under excessive utilization. Sparse stands of Santa Rita threeawn and Rothrock grama are characteristic of ranges with a long history of heavy use. Average herbage production of perennial grasses was greatest on light-use zones and least in heavy-use zones. Perennial grass stands near water were improved by closing waters during the growing season.

235. **Martin, S. Clark. 1973a. A grazing system for semidesert ranges based on responses of grasses to seasonal rest. *In:* Abstracts of Papers: 26th Annual Meeting, Society for Range Management; 1973 February; Boise, ID. Denver, CO: Society for Range Management: 21.**

The Santa Rita grazing system is discussed.

236. **Martin, S. Clark. 1973b. Responses of semidesert grasses to seasonal rest. Journal of Range Management. 26(3): 165-170.**

Perennial grasses on semidesert range in southern Arizona increased more in 8 years under spring-summer (March-October) rest for 2 out of 3 years, than under continuous yearlong grazing or any of 13 other rest schedules. A three-pasture grazing system that provides spring-summer rest for 2 years in 3 is being tested on SRER.

237. **Martin, S. Clark. 1975a. Ecology and management of southwestern semidesert grass-shrub ranges: The status of our knowledge. Research Paper RM-156. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 39 p.**

The vegetation on much southwestern semidesert range has shifted from grassland to brush since livestock ranching began 100 years ago. Shrub control, reseeding, and improved grazing management have reversed the downward trend on some ranges but most ranges are producing below their potential. Grazing will continue to be a major use for semidesert range despite high land prices and increased recreational activity from an expanding urban population. The role of ranges in meat production will become more important as increased population requires that arable lands be used mainly for food production. Additional research needs include the evaluation of improved grazing systems; prescribed burning; and impacts of range improvement practices on wildlife, scenic beauty, and other recreational attributes.

238. **Martin, S. Clark. 1975b. Stocking strategies and net cattle sales on semidesert range. Research Paper RM-146. Fort Collins, CO: U.S. Department of Agriculture, ForestService, Rocky Mountain Forest and Range Experiment Station. 10 p.**

The impact of variable forage yields on income from semidesert range was simulated over a 29-year period for several stocking strategies. Stocking factors evaluated were cull age for cows, age of cows at first calf, number of cows per 100 animal units total stocking, several levels of constant stocking, and two plans of flexible stocking.

Results indicate that the cow herd should be maximized, that cows should be bred to calve at age 2 and culled at age 8, and that constant stocking at 90% of average proper stocking produces relatively high income as well as relatively low risk of overstocking.

239. Martin, S. Clark. 1975c. Why graze semidesert ranges? Journal of Soil and Water Conservation. 30(4): 186-188.

Enough beef is produced for 2.89 million Americans, assuming an annual consumption of 120 pounds per capita. Rangeland grazing is an energy efficient alternative to beef production. Ranching is a way of life rather than an investment in some instances.

240. Martin, S. Clark. 1978a. Grazing systems--what can they accomplish? Rangeman's Journal. 5(1): 14-16.

The general objectives of a grazing system are to provide for the needs of forage plants, to encourage efficient and well-distributed forage utilization, and to promote efficient livestock production consistent with the capability of the land to sustain grazing. A complex grazing system should supply as many months of animal use as if the range were grazed continuously. It should provide enough rest, for enough time and at the right season, to meet the needs of the important forage plants. It should make full use of each year's forage without overgrazing. And it should provide acceptable, if not maximum, animal gains. Good systems alternately favor first the plant, then the animal, to meet the long-term needs of both.

241. Martin, S. Clark. 1978b. The Santa Rita grazing system. *In:* Nyder, Donald N., ed. Proceedings of the First International Rangeland Congress; 1978 August 14-18; Denver, CO. Denver, CO: Society for Range Management: 573-575.

The Santa Rita Grazing System is a 1-herd, 3-pasture, 3-year rotation geared to the growth habits of perennial grasses on the semidesert ranges of this area. The rest-grazing sequence is: rest 12 months (November - October), graze 4 months (November - February), rest 12 months (March - February), then graze 8 months (March - October) to complete the cycle. Each pasture is rested during both spring and summer growth periods 2 years out of 3, but each year's forage is utilized. A full year of rest before spring grazing provides old herbage that protects early growth from repeated close grazing. Benefits are greatest where animals congregate, like around water.

242. Martin, S. Clark. 1983. Responses of semi-desert grasses and shrubs to fall burning. Journal of Range Management. 36: 604-610.

Fire top-killed most small mesquites, killed almost all of the burroweed, and killed much of the cactus, except in unburned patches. Within 5 years regrowth of mesquite and newly established stands of burroweed equalled or exceeded pre-burn levels. Lehmann lovegrass increased following the burn; most other perennial grasses were not greatly affected. Results suggest that periodic burning can maintain a grassland aspect if the intensity and frequency of grazing allow enough dry herbage for an effective fire to accumulate between burns.

243. Martin, S. Clark. 1986. Values and uses for mesquite. *In:* Patton et al., tech. coords. Management and utilization of arid land plants. General Technical Report RM-135. Fort Collins, CO: U.S. Department of Agriculture, Forest Service: 91-96.

Live mesquite can provide food and shelter for wildlife, domestic livestock and man but may displace more efficient plants in the process. Mesquite wood has many uses including domestic fuel and a possible source of energy for industry. To be economical mesquite products must compete with available alternatives.

244. Martin, S. Clark. 1987. Converting forage to food with cattle on the Santa Rita Experimental Range. *In:* Aldon et al., tech. coords. Strategies for classification and management of native vegetation for food production in arid zones. General Technical Report RM-150. Fort Collins, CO: U.S. Department of Agriculture, Forest Service: 179-181.

Perennial grasses are the most productive forage plants on the SRER but shrubs such as velvet mesquite, and annuals enhance forage quality at times. Moderate stocking and suitable rotation schedules are essential for sustained high yields.

245. Martin, S. Clark; Barnes, Kenneth K.; Bashford, Leonard L. 1966. You can weigh a range cow before she knows it. Progressive Agriculture in Arizona. 18(6): 8-9.

An experimental scale for weighing range cattle was installed at SRER to force each individual animal to cross the scale platform on the way to water. Weight is recorded electrically on a strip-chart using strain-gage transducers. The system avoids the usual weight loss caused when cattle are disturbed by gathering, sorting, and weighing. Weight changes can be related to weather or vegetation. The present model costs $3,000 to $4,000 and requires an operator; refinements are being tested.

246. Martin, S. Clark; Barnes, Kenneth K.; Bashford, Leonard. 1967. A step toward automatic weighing of range cattle. Journal of Range Management. 20(2): 91-94.

A battery-operated electronic scale recorded range cattle weights accurately on oscillograph charts without disturbing the animals. With refinement, the system could operate automatically.

247. Martin, S. Clark; Cable, Dwight R. 1962. Grass production high 14 years after mesquite control. Arizona Cattlelog. 18(12): 58-61.

Grass production increased most at higher elevations where summer rainfall averaged 8.5 inches or more. Annual grasses were more important in lower elevations.

248. Martin, S. Clark; Cable, Dwight R. 1974. Managing semidesert grass-shrub ranges: Vegetation responses to precipitation, grazing, soil texture, and mesquite control. Technical Bulletin RM-1480. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 45 p.

In a 10-year study, perennial grasses increased in response to favorable rainfall and mesquite control and did better on fine- than on coarse-textured soils. Because of heavy spring use, grazing November-April was less favorable for perennial grasses than May-October or yearlong grazing.

249. Martin, S. Clark; Morton, Howard L. 1980. Responses of false mesquite, native grasses and forbs, and Lehmann lovegrass after spraying with picloram. Journal of Range Management. 33(2): 104-106.

Aqueous sprays of picloram at the rate of 0.56 kg/ha (94 1/ha total volume) were applied to 5 plots each in May 1973 and August 1976 to control falsemesquite (*Calliandra eriophylla*) in southern Arizona. Falsemesquite was effectively controlled on both spraying dates. The greatest vegetation change on sprayed and unsprayed plots alike was the overwhelming natural increase in density and yield of lehmann lovegrass, an introduced species. Perennial forbs were almost completely eliminated and densities of native perennial grasses were greatly reduced both on treated and untreated plots.

250. Martin, S. Clark; Reynolds, Hudson G. 1973. The Santa Rita Experimental Range: Your facility for research on semidesert ecosystems. Journal of the Arizona Academy of Science. 8: 56-67.

The range and its history are described to give the working ecologist an idea of the variety and scope of information available from 70 years of research on the impacts of grazing on the ecosystem, and relationships between flora, fauna, climate, and soils.

251. Martin, S. Clark; Severson, Keith E. 1988. Vegetation response to the Santa Rita grazing system. Journal of Range Management. 41(4): 291-295.

Changes in vegetation under yearlong grazing were compared with those under the Santa Rita grazing system, a rotation system designed for southwestern rangelands where 90% of the forage is produced in mid to late summer. Average herbage yields of pastures were not related significantly to grazing treatments but correlated strongly with historic summer rainfall means. Results support the observation that rotation grazing may not improve ranges that are in good condition.

252. Martin, S. Clark; Thames, John L.; Fish, Ernest B. 1974. Changes in cactus numbers and herbage production after chaining and mesquite control. Progressive Agriculture in Arizona. 25(6): 3-6.

Chaining was very effective in reducing total numbers of cholla and barrel cactus but had little overall impact on the prickly pear. Herbage production was significantly greater on treatments than check areas.

253. Martin, S. Clark; Tschirley, Fred H. 1962. Mesquite seeds live a long time. Progressive Agriculture in Arizona. 14(1): 15.

Seeds of velvet mesquite from a herbarium sheet germinated after 50 years. Seeds buried in the soil have germinated after 10 years. Another germination test will be made when the seeds have been in the soil 20 years.

254. Martin, S. Clark; Tschirley, Fred H. 1969. Changes in cactus numbers after cabling. Progressive Agriculture in Arizona. 21(1): 16-17.

Cholla plants increased after cabling for about 2-3 years and then declined in number to even lesser numbers than before treatment 6 years later. Cabling just to kill cactus may not be justifiable or economical.

255. Martin, S. Clark; Turner, Raymond M. 1977. Vegetation change in the Sonoran Desert region, Arizona and Sonora. Arizona Academy of Science. 12(2): 59-69.

Six sets of photographs are used to show changing vegetation conditions on semidesert grasslands and Sonoran desert sites.

256. Martin, S. Clark; Ward, Donald E., Jr. 1966. Using aerial applications--two annual sprays control mesquite. Progressive Agriculture in Arizona. 18(6): 20-21.

Mesquite can be effectively controlled by two aerial applications of 2,4,5-T applied a year apart. Project costs ranged from 3 to 5 dollars per acre. Increases in grass production repaid the cost in 3 years.

257. Martin, S. Clark; Ward, Donald E. 1970. Rotating access to water to improve semidesert cattle range near water. Journal of Range Management. 23(1): 22-26.

Seasonal opening and closing of watering places in a 3,200-acre pasture on SRER resulted in lighter use of perennial grasses near water if utilization of the pasture was moderate to light and if the closed period included the summer growing season. Rotating use of watering places should work best in large range units with waters far apart.

258. Martin, S. Clark; Ward, Donald E. 1973. Salt and meal- salt help distribute cattle use on semidesert range. Journal of Range Management. 26(2): 94-97.

Cows on semidesert grass-shrub range ate less than 1/2 lb per day of 3:1 meal-salt mix when it was fed 1 to 2½ miles from water. No injury to cattle due to either inadequate or excessive salt intake was observed. Compared to feeding at water, placing salt or meal-salt 1 to 2½ miles from water increased average utilization of perennial grasses where use was usually light, but it did not materially decrease use near water.

259. Martin, S. Clark; Ward, Donald E. 1976. Perennial grasses respond inconsistently to alternate year seasonal rest. Journal of Range Management. 29(4): 346.

Several schedules of alternate-year grazing and rest were compared with continuous yearlong grazing and with winter rest every year on small plots over a 7-year period. Differences among treatments were not significant. Results suggest that alternate-year rest schedules do not provide enough growing season recovery time between growing seasons.

260. McCormick, Dale Patrick. 1975. Effect of mesquite control on small game populations. Tucson, AZ: University of Arizona. 66 p. M.S. thesis.

Comparisons of ground cover and abundances of seven species of small game were made between a mesquite-controlled and a mesquite-invaded pasture. While control of medium-dense stands of mesquite (15-100 trees per acre) did not significantly increase total perennial grass ground cover over a 10-year period, it decreased use by mourning and white winged doves, Gambel's and scaled quail, and desert cottontail rabbits. Antelope and black-tailed jackrabbit abundances were relatively unaffected.

261. McGinnies, W. G. 1941. Unused winter annuals are not lost. Western Livestock Journal. 19(34): 8-9.

Annuals are often the principal source of litter and humus. They act as buffers to the advancing front of the desert. Stockmen who graze lightly or not at all will find this nonuse is the best investment.

262. McGinnies, W. G; Arnold, J. F. 1939. Relative water requirements of Arizona range plants. Technical Bulletin 80. Tucson, AZ: University of Arizona, Agricultural Experiment Station. 246 p.

The water requirements of 28 species of Arizona range plants and 5 crop plants were determined under varying climatic conditions during the period 1931 to 1936. Results obtained for crop plants were used as a basis for comparison of climatic conditions at Akron, Colorado, and elsewhere in the Great Plains area.

263. McNellis, Terry Allen. 1968. The effects of mestranol upon native desert rodent populations. Tucson, AZ: University of Arizona. 49 p. M.S. thesis.

Field trials revealed a significant reduction in testes size and sperm production in *Dipodomys merriami*. Mestranol lacked the long-term effects necessary to reduce and control a polytocous desert rodent species.

264. Medina, Alvin L. 1981. Range research and resource management in southern Arizona. *In:* Patton et al., tech. coords. Wildlife and range research needs in northern Mexico and southwestern United States. General Technical Report WO-36. Washington, DC: U.S. Department of Agriculture, Forest Service: 104-108.

Summarizes five field-day presentations given by various authorities on range research, resource management, and ranch management in southern Arizona. Emphasis is given to range research on the SRER and resource management on the Coronado National Forest.

265. Medina, Alvin L. 1988. Diets of scaled quail in southern Arizona. Journal of Wildlife Management. 52(4): 753-757.

Seeds of forbs and woody plants composed >57% of the volume of quail diets. Green herbage composed 16% of diets during February through June. Grass seeds were eaten in large amounts (12.1-56.5%) only from September through November. Insects were consumed primarily in March through August. Lehmann lovegrass stands produced comparatively low amounts of forbs and high perennial grass cover. Quail were most abundant in areas with low perennial grass cover and high forb cover.

266. Mehrhoff, Loyal A., Jr. 1955. Vegetation changes on a southern Arizona grassland range--an analysis of causes. Tucson, AZ: Department of Agronomy and Range Management, University of Arizona. 49 p. M.S. thesis.

There have been no changes in the climate that would permit the invasion of grasslands by shrubby species. Introduction of grazing animals has had an adverse effect on the grassland vegetation. Cattle and rodents are important factors affecting the rate of shrub invasion. Fires have maintained the grasslands and subsequent control has been to the advantage of shrubby species.

267. Mehuys, G. R.; Stolzy, L. H.; Letey, J. Jr., Weeks, L. V. 1974. Evaluation of critical soil properties needed to predict soil water flow under desert conditions. US/IBP Desert Biome Research Memorandum 74-45. Logan, UT: Ecology Center, Utah State University. 14 p.

Moisture movement induced by thermal gradients in sealed soil columns was studied under steady-state conditions. For Tubac and Rillito soils, water content in the soil columns remained unchanged during the experiments because the initial water contents were too high. In studies with "Rock Valley" soil, thermal moisture diffusivity L_{wq} decreased from 14.0 to 1.3 x 10^{-3} $cm^2hr^{-1}deg^{-1}$ as $\bar{R}$ decreased from 0.14 to 0.08, indicating that much of the moisture movement from hot to cold regions probably occurred in the liquid phase. However, the values of L_{wq} were scattered and the influence of stones on this coefficient could not be determined from the experimental data.

268. Merz, August. 1985. Mountain-front recharge from the Santa Rita Mountains to the Tucson basin. Tucson, AZ: Department of Hydrology and Water Resources, University of Arizona. 122 p. M.S. thesis.

This study reports on recharge characteristics relative to geological substrates of various sites on the western front of the Santa Rita Mountains.

269. Metto, Paul Kimngeny. 1971. Control of catclaw (*Acacia greggii*) with Picloram in southern Arizona. Tucson, AZ: University of Arizona. 46 p. M.S. thesis.

Foliar spray treatments at 1- and 3-pound rates resulted in over 90% defoliation for all treatment dates (August through July) except in April and May. Granular treatments were not as effective as the liquid formulation. Granules were most effective in summer when applied at the 1-pound rate.

270. Mirreh, Mohamed Mohamud. 1982. Sensitivity of frequency and canopy cover to changes in vegetation. Tucson, AZ: University of Arizona. 47 p. M.S. thesis.

Significant differences between species of five stands were greater for the frequency method than canopy coverage method. Both methods were highly correlated to the importance value. The canopy coverage method was a more sensitive measure of difference resulting from utilization between those areas excluded from grazing and those open to grazing. The ephemeral nature of canopy cover reduces its value for trend analysis. Adequate sample size for the canopy cover method in desert grassland was estimated as 6 to 8 transects of 20 quadrats for total cover.

271. Morton, Howard L.; Moffett, Joseph O.; Martin, Richard D. 1974. Influence of water treated artificially with herbicides on honey bee colonies. Environmental Entomology. 3(5): 808-812.

Apis mellifera L. colonies were placed in isolated desert apiaries where their only source of water contained paraquat (concentration of 1000 part per million active ingredient by weight (ppmw)). Large numbers of bees exposed to paraquat died immediately, and all were dead before the end of the 5th week. When colonies were similarly exposed to like amounts of 2,4,5-T, large numbers of bees drowned in the water because of the lower surface tension of the water, and production of brood was reduced below that of check colonies during the period the treated water was used and for 3 months thereafter. In the subsequent 9 months, however, production returned to normal. Concentrations of 2,4,5-T in honey bees from colonies using water containing 2,4,5-T were as high as 148 ppmw, but this level dropped to about 5 ppmw as soon as the bees began using untreated water. Likewise, honey from colonies using water containing 2,4,5-T contained concentrations of 2,4,5-T as high as 50 ppmw; however, the concentration dropped to about 5.0 ppmw within 1 week after the bees began using untreated water. The last day when any 2,4,5-T was detected in honey bees and honey from treated colonies was 480 days after the experiment began. Wax from colonies using the treated water contained detectable amounts of 2,4,5-T 650 days after the study was initiated.

272. Mukhtar, Hashim A. M. 1961. Factors affecting seed germination of some important desert plants. Tucson, AZ: University of Arizona. 54 p. M.S. thesis.

Mechanical scarification increased germination rate of all species. *Andropogon gayanus, Eragrostis superba* and *E. trichodes* had very low germination rates following sulfuric acid treatment. In vitro tests using sulfuric acid treatments inhibited germination in three species but worked well on *Prosopis juliflora* and *Acacia mellifera*. Most species germinated at a temperature range of 28°C to 36°C. Germination of different species was promoted under different spectral bands.

273. Murray, Steven Lee. 1972. Foraging of the leaf-cutter ant, *Acromyrmex versicolor* Perg., in relation to season, temperature, relative humidity and rainfall. Tucson, AZ: University of Arizona. 23 p. M.S. thesis.

Workers foraged in columns along trail routes and used different forage sources through the study. Daily foraging period was nocturnal in summer, crepuscular in spring and fall, and diurnal in winter. Rainfall induced maximum seasonal foraging, and maximum annual foraging was concurrent with the summer rains. Active foraging occurred in the air temperature of 8.5°C to 31.5°C and relative humidity range from 12% to 87%.

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276. Nakasone, Karen Kikumi. 1977. Fungi that decay ocotillo in Arizona. Tucson, AZ: University of Arizona. 77 p. M.S. thesis.

Twenty-six wood-rotting basidiomycetes and one ascomycete are reported from ocotillo for the first time. Two new species, *Hyphoderma fouquieriae* and *Cristinia sonorae* are described. Cultural characteristics of 21 fungi are included. *H. fouquieriae* was found to be heterothallic with a bipolar mating system. *Panus fulvidus* was the only known brown rot fungus.

277. Nascimento, Hoston Tomas Santos. 1988. Pattern of utilization and response of Lehmann lovegrass (*Eragrostis lehmanniana* Nees) grazed by cattle. Tucson, AZ: Department of Nutritional Sciences, University of Arizona. 195 p. Ph.D. dissertation.

This study reports on patterns of utilization of lehmann lovegrass by cattle during different seasons at three stocking rates on four patch types. Total biomass was higher at moderate followed by heavy and very heavy stocking rates. Green biomass (kg/ha) was higher at moderate followed by very heavy and heavy stocking rates. Height of leaves and flowers were greater at moderate followed by heavy and very heavy stocking rates. Protein, phosphorus, calcium, and neutral detergent fiber contents were higher in green than in complete samples. Height of leaves and flowers, dry biomass, green biomass, and total biomass were greater on ungrazed patches. Cattle grazed for an average of 7 hours during the 14-hour period of observation. Grazing was concentrated on previously grazed patches. At all stocking rates, cattle grazed more in open patches. Cattle grazed uplands, open grazed patches, and under mesquite canopy. These areas were higher in proportion of green biomass and nutrient value and lower in total standing crop and total green biomass than ungrazed areas. Nutrient density, rather than biomass, appeared to govern cattle grazing.

278. Nutting, W. L.; Haverty, M. I; LaFage, J. P. 1973. Colony characters of termites as related to population density and habitat. US/IBP Desert Biome Research Memorandum 73-30. Logan, UT: Ecology Center, Utah State University. 17 p.

Five major woody plants and many lesser species have contributed an estimated accumulation of 2,589 kg/ha of fallen dead wood at SRER. Foraging populations and biomass estimates for the four most important species of termites are as follows: *Amitermes wheeleri* (subterranean), 19.0 foraging groups, 2,375 foragers or 1.1 g/ha; *Paraneotermes simplicicornis* (dry-wood), 7.5 groups, 4,683 foragers or 11.0 g/ha; *Heterotermes aureus* (subterranean), 95,750 foragers or 33.1 g/ha; *Gnathamitermes perplexus* (subterranean), 705,200 foragers or 484.7 g/ha. Incipient colonies of *Marginitermes hubbardi* (dry-wood), started from paired alates, attained a mean colony size of 6.42 individuals (range 3-14) after 1 year at 32°C.

279. Nutting, W. L.; Haverty, M. I.; LaFage, J. P. 1974. Colony characters of termites as related to population density and habitat. US/IBP Desert Biome Research Memorandum 73-33. Logan, UT: Ecology Center, Utah State University. 18 p.

Preliminary results show foraging intensities and wood consumption rates of two major subterranean termites are temperature dependent. Wood consumption rates are provided, as well as other energetic data.

280. Nutting, W. L.; Haverty, M. I.; LaFage, J. P. 1975. Demography of termite colonies as related to various environmental factors: Population dynamics and role in the detritus cycle. US/IBP Desert Biome Research Memorandum 75-31. Logan, UT: Ecology Center, Utah State University. 26 p.

Estimates of surface dead wood production and standing crop biomass on the SRER site remain at 450 kg $ha^{-1}yr^{-1}$ and 2127 kg/ha. Instantaneous estimates of mean surface foraging numbers of the 5 most important subterranean species are 6.89, 0.35, 1.31, 1.51 and 0.12 termites/m^2. Estimated total number for all five species is 1,025/m^2 with a biomass of 0.414 g/m^2. Superficial dead wood and termites are not randomly dispersed. The abundance of particular oligophagous termites is correlated with the quantity of highly preferred woods, while there is no correlation between the abundance of polyphagous species and wood species. Each termite species maintains a rather exclusive niche through a characteristic mode of attack on a preferential selection of host woods. *Heterotermes* and *Gnathamitermes* forage throughout the year under a wide range of temperatures, with foraging intensity regulated primarily by temperature and modified by soil moisture.

281. Nutting, W. L.; Haverty, M. I.; LaFage, J. P.; Carr, R. V. 1972. Colony characters of termites as related to population density and habitat. US/IBP Desert Biome 1971 Progress Report. Logan, UT: Ecology Center, Utah State University. 12 p.

Population and biomass estimates for three species of termites at Santa Rita are as follows: *Pterotermes occidentis* (dry-wood), 4.8 colonies/ha, 104.2 termites/ha or 0.48 g/

ha; *Heterotermes aureus* (subterranean), 140.7 foraging groups/ha, 23,770 foragers/ha or 8.2 g/ha; *Gnathamitermes perplexus* (subterranean), 705,200 foragers/ha or 374.3 g/ha. Foraging of *Heterotermes* is limited by upper level soil temperatures between ca. 8 and 35°C.

282. Nutting, William L.; Haverty, Michael L. 1976. Seasonal production of alates by five species of termites in an Arizona desert grassland. Sociobiology. 2(2): 145-153.

Production of winged termites was determined to be 47,286 alates/ha with a dry weight of 174 g in 1974. *Heterotermes aureus* and *Gnathamitermes perplexus* produced alates at the rate of 0.04% and between 0.11-0.13% of their total populations during the poorest and third poorest years for alate production since 1961. Flights occur on or shortly after the first few evenings of "sufficient" rainfall. Later in the flight season "sufficient" rainfall may not result in flights, perhaps because all the alates have flown. Total rainfall for each flight season was very different; however, there was very little difference in the total number of alates produced each season. These relatively stable insect societies can thus produce a seasonally dependable, energy-rich food source in the form of winged life forms for a variety of predators.

283. Olding, Ronald J.; Cockrum, E. Lendell. 1977. Estimation of desert rodent populations by intensive removal. Journal of the Arizona Academy of Science. 12: 96-108.

The Standard Minimum Method was found to have a relatively high degree of reliability for estimating small nocturnal rodents, given certain assumptions are true. Drawbacks to the method are discussed.

284. Olding, Ronald James, Jr. 1976. Estimation of desert rodent populations by intensive removal. Tucson, AZ: University of Arizona. 60 p. M.S. thesis.

Densities for total animals ranged from 11.4 to 107.3 animals per hectare. Heavy rainfall negatively affected capture success. Minor species often displayed a nonuniform probability of capture. For total animals and major species, a 5-day trapping period preceded by 2 days of prebaiting gave reliable population estimates.

285. Osman, Mohamoud Abdullahi. 1982. Chemical composition and digestibility of Lehmann lovegrass (*Eragrostis lehmanniana*) in response to grazing and clipping intensities. Tucson, AZ: University of Arizona. 67p. M.S. thesis.

All measures of forage quality were constantly higher in continuous grazed plots during the summer-fall period. Forage quality was higher in the periodic grazed plots during late fall and early winter. Mean standing crop sampled from protected plots averaged 1550 kg/ha to 1600 kg/ha. Monthly removal of 10, 20, and 30 grams of the available herbage resulted in a reduction in forage quality.

286. Owtadolajam, Esmail. 1982. Herbage production as a function of soil moisture stress in a semiarid area. Tucson, AZ: School of Renewable Natural Resources, University of Arizona. 138 p. Ph.D. dissertation.

A soil water budgeting model that uses the initial soil water content was developed and tested. Calculated stress was correlated to the yield and stepwise multiple regression were used to produce prediction equations.

287. Parker, Kenneth W. 1939a. The control of burroweed. Research Note 72. Tucson, AZ: U.S. Department of Agriculture, Forest Service, Southwestern Forest and Range Experiment Station. 4 p.

The method of eradication should be the one best suited to a particular situation. In extremely rocky areas burning or spraying is better than grubbing. Grubbing and burning gave most consistent results.

288. Parker, Kenneth W. 1939b. Management of livestock to avoid losses from poisonous plants. Research Note 70. Tucson, AZ: U.S. Department of Agriculture, Forest Service, Southwestern Forest and Range Experiment Station. 4 p.

Early use, especially at high elevations, should be avoided since toxic plants are most abundant at that time. Other opportunities are to change from cattle to sheep grazing on pingue-infested ranges, or defer use on such areas to a later date. Riding or herding is also recommended to keep animals away from sites with noxious plants.

289. Parker, Kenneth W. 1940a. Management of livestock to avoid losses from poisonous plants. The Cattleman. 26(10): 69-70.

Supplemental information is provided for ranchers on how to handle livestock to avoid losses from death or decreased production due to poor livestock condition. Suggested approaches include changes in class of livestock, deferment from grazing during given phenological stages, and fencing.

290. Parker, Kenneth W. 1940b. Mesquite can be killed by arsenic solution. Western Livestock Journal. 18(56): 10.

Recommendations for use of arsenic in the control of *Prosopis velutina* are given. Other information includes costs, time of application, and precautions.

291. Parker, Kenneth W. 1940c. Use of arsenic in the control of mesquite in the Southwest. The Cattleman. 27(7): 89-90. [Also published as USDA Forest Service Research Note 88, Tucson, AZ: U.S. Department of Agriculture, Forest Service, Southwestern Forest and Range Experiment Station.]

Refer to Parker 1940b.

292. Parker, Kenneth W. 1942. A method for estimating grazing use in mixed grass types. Research

Note 105. Tucson, AZ: U.S. Department of Agriculture, Forest Service, Southwestern Forest and Range Experiment Station. 5 p.

A method is described that has been applied on SRER and has proven to be satisfactory. The method also provides an excellent check on the examiner's judgment of floristic composition.

293. Parker, Kenneth W. 1943a. Control of mesquite on southwestern ranges. Leaflet No. 234. Washington, DC: U.S. Department of Agriculture. 8 p.

Various mechanical and chemical techniques of mesquite control are discussed.

294. Parker, Kenneth W. 1943b. Market'em when they're ready. The Cattleman. 30(4): 96, 98.

In the southwest, livestock gains are made mainly through the growing season, July through September. Range forage quality declines in October, except on good condition range where gains are possible until mid-October. Calves should be marketed during October and early November.

295. Parker, Kenneth W. 1943c. Southwestern stockman--play to win! Pub. AWI-74, Washington, DC: U.S. Department of Agriculture. 15 p.

The basis for "conservative stocking" is discussed.

296. Parker, Kenneth W. 1944a. Adjust range stocking for heavier animals. The Cattleman. 31(3): 17, 18, 38, 39.

Suggested stocking strategies are provided to ranchers in order to maintain healthy herds during drought conditions. The main objective is to adjust stocking to the forage supply and to point out the best policy for the Southwestern rancher to pursue in handling his herd for the longtime good of the industry and the range resource.

297. Parker, Kenneth W. 1944b. The control of mesquite on southwestern ranges. Sheep and Goat Raiser. 24(10): 14, 15, 35, 36.

This study reports on various methods of controlling the spread of mesquite on southwestern rangelands, namely, grubbing by hand, clearing with power machinery, spraying with kerosene or diesel oil, and poisoning with sodium arsenite.

298. Parker, Kenneth W. 1944c. Southwestern stockman--play to win. Coastal Stockman. 9(12): 12-44.

Refer to Parker 1943b.

299. Parker, Kenneth W.; Glendening, George E. 1942. General guide to satisfactory utilization of the principal southwestern range grasses. Research Note 104. Tucson, AZ: U.S. Department of Agriculture, Forest Service, Southwestern Forest and Range Experiment Station. 4 p.

Utilization recommendations for 33 species of grasses are given. Additional data is provided on proper use factors relative to range condition.

300. Parker, Kenneth W.; Martin, S. Clark. 1943. Beetle helps control burroweed invasion. Arizona Stockman. 9(5): 4, 16.

The principal parasites attacking burroweed are small beetles. The larvae, commonly known as round-head borers, live within the roots and lower stem. Several studies have been conducted to find means of controlling burroweed, with grubbing the most effective. Reports of insect damage on burroweed are provided.

301. Parker, Kenneth W.; Martin, S. Clark. 1952. The mesquite problem on southern Arizona ranges. Circular 908. Washington, DC: U.S. Department of Agriculture. 70 p.

The authors discuss the problem and effects of mesquite invasion of grasslands. Methods for control and elimination are emphasized.

302. Parker, Kenneth W.; McGinnies, W. G. 1940. Seeding southwest ranges. American Hereford Journal. 31(6): 23. [Also published as USDA Forest Service Research Note 86. Tucson, AZ: U.S. Department of Agriculture, Forest Service, Southwestern Forest and Range Experiment Station.]

A list of suitable species and the localities where they may be planted is presented along with recommended conditions and methods of range reseeding.

303. Parker, Kenneth W.; McGinnies, W. G. 1942. Mesquite, the silent invader. The Cattleman. 27(12): 35, 38-40.

The strategies by which mesquite germinates and expands its range are discussed.

304. Pase, Charles P. 1971. Effect of a February burn on Lehmann lovegrass. Journal of Range Management. 24(6): 454-456.

Density and vigor of lehmann lovegrass were essentially unaffected by burning that resulted in a 90% topkill of shrub live oak sprouts. Some increases were noted in King Ranch and yellow bluestem and associated native forbs.

305. Pase, Charles P.; Granfelt, Carl Eric, tech. coords. 1977. The use of fire on Arizona rangelands. Arizona Interagency Range Community Publication. 4: 15.

Recommendations are provided for using fire to accomplish desired benefits on pinyon-juniper woodland, interior chaparral, sonoran desert shrub, desert-grassland, shortgrass, sagebrush, and ponderosa pine ranges.

306. Paulsen, Harold A., Jr. 1950. Mortality of velvet mesquite seedlings. Journal of Range Management. 3(4): 281-286.

At the close of the second growing season, seedling mortality was 96%, 94%, and 47% under the following levels of protection: open to yearlong grazing by cattle and rodents, cattle exclusion, and protection from cattle and rodents. Mortality factors included native rodents, subnormal rainfall, and low winter temperatures.

307. Paulsen, Harold A., Jr. 1953. A comparison of surface soil properties under mesquite and perennial grass. Ecology. 34(4): 727-732.

The laboratory analyses indicate the soil under the mesquite cover to be deteriorated in both chemical and physical properties. The latter is of greater importance since the indicated reduction in the nutrient capital is not believed to have reached the minimal requirements of the grasses. Soil under the mesquite was coarser, lower in pore volume, and higher in volume-weight. Soil structure and moisture relations were apparently less favorable and there was shown to be more instability of the surface soil under mesquite.

308. Pearthree, Philip A. 1981. Quaternary faulting along the eastern margin of the Santa Cruz River valley south of Tucson, Arizona. *In:* Geosciences Daze, Ninth Annual Colloquium; 1981 March 4-6; Tucson, AZ. Tucson, AZ: Department of Geosciences, University of Arizona. p. 27.

Scarp profile data indicate their age to be approximately 105 years old. A chronosequence of alluvial geomorphic surfaces has been established. Surface ages are inferred to range from early Pleistocene or older to late Holocene.

309. Powers, William Riley, III. 1969. The influence of sodium chloride and gravel treatments on infiltration. Tucson, AZ: Department of Watershed Management, University of Arizona. 80 p. M.S. thesis.

No significant treatment effects upon infiltration capacities were found. All plots showed an increase in infiltration capacity after treatment. A decrease in bulk density caused by insect activity and latent root growth of spring annuals might be the cause for increased infiltration capacities. Simulated raindrop size and natural and system variation caused lack of significant results.

310. Price, Mary V. 1977. Validity of live trapping as a measure of foraging activity of heteromyid rodents. Journal of Mammalogy. 58(1): 107-110.

Live-trapping of some desert-dwelling heteromyid rodent species strongly reflected their place of foraging. Two independent methods were used concurrently to measure microhabitat preferences of heteromyids. Both methods were effective in measuring foraging microhabitat preferences.

311. Price, Mary V. 1978. The role of microhabitat in structuring desert rodent communities. Ecology. 59(5): 910-921.

Experiments were conducted with four coexisting desert rodent species to see whether competition is a sufficient explanation for their resource use and abundance patterns. Results were consistent with three predictions from competition theory: (1) the four species differed in their use of a resource, foraging microhabitat, which is potentially limiting to their populations; (2) each species shifted its use of microhabitats in predicted directions when competitors were removed from or added to outdoor enclosures; and (3) each species was most dense where its preferred microhabitat was abundant, and augmentation of one microhabitat led to an increase in the density of the appropriate microhabitat specialist. These results suggest that competition maintains interspecific differences in foraging microhabitat and that the availability of appropriate microhabitats determines species abundances on a local scale.

312. Price, Mary Vaughan. 1976. The role of microhabitat in structuring desert rodent communities. Tucson, AZ: Department of Ecology and Evolutionary Biology, University of Arizona. 81 p. Ph.D. dissertation.

Enclosure experiments were used to see if resource use by seed-eating rodents changed in response to the presence of competitors. Perturbation experiments assessed the effect of resource availability on species abundances. Results suggest competition maintains interspecific differences in the microhabitats from which seeds are gathered, and that the availability of appropriate microhabitats determines patterns of species abundance on a local scale.

313. Qashu, H. K.; Evans, D. D.; Wheeler, M. L.; Sammis, Theodore. 1973. Water uptake by plants under desert conditions. US/IBP Desert Biome Research Memorandum 73-42. Logan, UT: Ecology Center, Utah State University. 27 p.

The observed moisture content variations in the root zone were related to precipitation-evaporation processes at the study site. Rooting habits of *Celtis pallida* were examined and related to moisture availability and soil structure. Data were collected on plant leaf potentials using pressure bomb techniques. The observed variations were related to both plant water use and to changes in the resistance to water flow through the plant. A model is described for analyzing the total resistance to water flow from the soil to the leaf.

314. Reid, Elbert H.; Kovner, Jacob L.; Martin, S. Clark. 1963. A proposed method of determining cattle numbers in range experiments. Journal of Range Management. 16(4): 184-187.

The procedure has been used to estimate grazing capacity of experimental pastures where rather intensive data on herbage production and utilization of the main species have been available. The method can be used to estimate stocking to meet a given herbage production.

315. Renard, K. G. 1978. The Southwestern Rangeland Watershed Research Center. Agricultural Engineering. 59(9): 19-21.

Studies at the center focus on determining water-resource potentials; establishing soil, water, and grazing management systems for increasing and stabilizing forage production; providing design concepts and criteria for flash flood and sedimentation control; and monitoring the movement of nonpoint-source pollutants.

316. Reynolds, H. G.; Bohning, J. W. 1956. Effects of burning on a desert grass-shrub range in southern Arizona. Ecology. 37(4): 769-777.

Authors report the effects of a single June burn upon undesirable woody plants, burroweed, cholla, mesquite, and pricklypear; desirable perennial grasses and shrubs; and soil constituents and properties.

317. Reynolds, H. G.; Glendening, G. E. 1949. Merriam kangaroo rat--a factor in mesquite propagation on southern Arizona rangelands. Journal of Range Management. 2(4): 193-197.

Merriam kangaroo rats collect mesquite seeds as a preferred food item. Not all the harvested seed is consumed, and a large portion is buried in shallow caches, where it germinates. As mesquite increases, perennial grass decreases, and greater numbers of Merriam rats occupy the habitat.

318. Reynolds, H. G.; Tschirley, F. H. 1956. Get rid of those mesquite--now. Arizona Stockman. 22(7): 15, 31, 36.

The main principles to be observed in a mesquite eradication program are: (1) treat those sites first where the greatest forage response can be expected; (2) complete eradication of mesquite from a range unit in preference to partial control; (3) eradication of the lightest stands pays the biggest dividends.

319. Reynolds, H. G.; Tschirley, F. H. 1957. Mesquite control on southwestern rangeland. Leaflet 421. Washington, DC: U.S. Department of Agriculture. 8 p. [Also published in 1958 in The Cattleman. 44(10): 44-45, 62.]

The detrimental effects of mesquite are discussed along with the value of control and the types of stands most suitable for control by grubbing, basal oiling, mechanical clearing, and airplane spraying.

320. Reynolds, H. G.; Tschirley, F. H. 1963. Mesquite control on southwestern rangeland. Leaflet 421 [revised]. Washington, DC: U.S. Department of Agriculture, Forest Service. 8 p.

Mesquite, which has been increasing steadily, reduces forage production of rangeland. Removal recommendations are: Trees less than 1-inch stem diameter should be grubbed, and larger trees can be killed with diesel oil or dozed. Where stands exceed 100 trees per acre, either foliage sprays or cabling and chaining are recommended.

321. Reynolds, Hudson G. 1947. Hope in range reseeding. Arizona Farmer. 27(17): 15, 17. Preliminary results of 25 different studies show promise of using selected grasses for revegetation trials. Planting recommendations are provided.

322. Reynolds, Hudson G. 1950. Relation of Merriam kangaroo rats to range vegetation in southern Arizona. Ecology. 31(3): 456-463.

Greater numbers of Merriam kangaroo rats were captured on grazed areas than on exclosures protected from livestock grazing for several years. Rat numbers tended to decrease as perennial grass density increased. Annual grass seed occurred most frequently in cheek pouch contents; perennial grass and forb seed ranked next in abundance, and seeds of woody plants, last. Perennial grass, mesquite, and cactus seed seemed to be preferred because of larger size. Seed of these plants was gathered entirely from the ground, whereas seed of other species was often harvested directly from the plant. Minute seeds were nearly always taken in whole fruits. Large-seeded perennial grass abundance on livestock-protected exclosures was influenced unfavorably by kangaroo rats during periods of low seed production but favorably during periods when abundant seed was available.

323. Reynolds, Hudson G. 1954a. Meeting drought on southern Arizona rangelands. Journal of Range Management. 7(1): 33-40.

This analysis defines drought, relates it to forage production and livestock adjustments, and describes some practices that can be used to reduce the disastrous effects of drought on southwestern ranges. New concepts of the nature of drought are presented.

324. Reynolds, Hudson G. 1954b. Some interrelations of the Merriam kangaroo rat to velvet mesquite. Journal of Range Management. 7(4): 176-180.

Merriam kangaroo rats (*Dipodomys merriami merriami* Mearns) increase in number as perennial grasses decrease, and, because of their seed-storing habits, contribute to the further spread of mesquite. An appraisal is made of the relative importance of this means of spread as compared to other possible agencies of mesquite dissemination.

325. Reynolds, Hudson G. 1958. The ecology of the Merriam kangaroo rat (*Dipodomys merriami* Mearns.) on the grazing lands of southern Arizona. Ecological Monographs. 28: 111-127.

The life history, habitat, and economic relations of the Merriam kangaroo rat to grazing lands are reported. Direct and indirect effects of precipitation and good range condition tend to hold the number low. On ranges in good to excellent condition, seed-burying habits of these rodents are probably of beneficial influence. On rangelands infested by cacti and mesquite, these same habits may favor accelerated spread of these undesirable plants.

326. Reynolds, Hudson G. 1959a. Brush control in the southwest. *In:* Grasslands, American Association for the Advancement of Science. 53: 379-389.

This paper discusses the major problem species of woody plants in Arizona and New Mexico, possible causes of their invasion, and some current methods of control used to suppress them.

327. Reynolds, Hudson G. 1959b. Managing grass-shrub cattle ranges in the southwest. Agriculture Handbook 162. Washington, DC: U.S. Department of Agriculture. 40 p.

A comprehensive review of management of grass-shrub cattle ranges of the Southwest, based on results of numerous studies conducted on SRER is provided. Characteristics of the climate and vegetation, range conditions, stocking rates, forage utilization, proper handling of livestock, and range improvement practices are discussed. These are summarized in nine recommendations for managing grass-shrub ranges.

328. Reynolds, Hudson G. 1960. Life history notes on Merriam's kangaroo rat in southern Arizona. Journal of Mammalogy. 41: 48-58.

Some aspects of reproduction, development, breeding habits, activity patterns, and home range are analyzed and discussed.

329. Reynolds, Hudson G. 1972. An albino Gambel quail from southern Arizona. Journal Arizona Academy of Science. 7(2): 46.

Albinism is apparently rare in Gambel quail (*Lophortyx gambelii*). This record is the first known formal report of albinism, even though the species has been studied extensively.

330. Reynolds, Hudson G.; Haskell, Horace S. 1949. Life history notes on Price and Bailey pocket mice of southern Arizona. Journal of Mammalogy. 30(2): 150-156.

Food items found in the cheek pouches consisted chiefly of large seeds of unimportant range plants. Seeds of desirable perennial grasses were not eaten in any quantity. Populations of pocket mice were found to be generally low, averaging about 3 acres per animal. The highest population occurred in ungrazed stands of perennial bunchgrass where abundance of plants was relatively greater. Because of the low numbers and inoffensive food habits, little or no concern need be given to pocket mice in the management of these particular ranges for domestic livestock grazing.

331. Reynolds, Hudson G.; Martin, S. Clark. 1968. Managing grass-shrub cattle ranges in the southwest. Agricultural Handbook 162 [revised]. Washington, DC: U.S. Department of Agriculture. 44 p.

Management of grass-shrub range is up to the individual rancher. He alone can control degree of use, season of use, and distribution of grazing. He can manipulate availability of water and salt, distribute grazing pressure, and suppress undesirable woody plants.

332. Rivers, William James. 1977. Predicting semidesert range perennial grass production from recent precipitation and grazing levels. Tucson, AZ: University of Arizona. 92 p. M.S. thesis.

Perennial grass production was shown to be dependent on the product of current precipitation. Use levels generally had weak negative effects on production. Range condition was found to be correlated with 10-year mean use but not with perennial grass production.

333. Rivers, W. James; Martin, S. Clark. 1980. Perennial grass improves with moderate stocking. Rangelands. 2(3): 105-106.

Results confirm that complete protection from cattle over long periods is not necessary for range recovery and that moderate stocking allows acceptable rates of recovery and improvement. It is especially important to reduce animal numbers in the fall following severe summer drought and to keep stocking down for at least one year after the drought ends.

334. Roach, Mack E. 1949. Controlling mesquite with dieseloil. Research Note 115. Tucson, AZ: U.S. Department of Agriculture, Forest Service, Southwestern Forest and Range Experiment Station. [Revision of Research Note 115 by Martin, S. Clark.]

Refer to Martin, S. Clark 1947b.

335. Roach, Mack E. 1950. Estimating perennial grass utilization on semidesert cattle ranges by percentage of ungrazed plants. Journal of Range Management. 3(3): 182-185.

The method employs a graph of the relation between the percent of plants ungrazed and the amount of forage removed.

336. Roach, Mack E. 1953. Controlling mesquite with diesel oil pays. Arizona Stockman. August: 16-17.

Control of mesquite resulted in a four-fold increase in perennial grass production. The increased forage realized would yield an annual gross return of about $1.75 per acre. An added benefit is ease of handling livestock.

337. Roach, Mack E.; Glendening, George E. 1954. Response of velvet mesquite in southern Arizona to airplane spraying with 2,4,5-T. Western Weed Control Conference Proceedings. 14: 53-56.

A study on SRER compared the effects of all combinations of: (1) an amine salt and a low-volatile ester of 2,4,5-T at 3/4 pound acid equivalent per acre, (2) application of 5, 10, and 20 gallons of solution per acre, (3) 1:3 and 1:7 oil-water emulsion as carriers, and (4) diesel oil and a nonphytotoxic form as the oil phase of the carrier. Tests of ester and amine forms of 2,4,5-T applied at the rates of 5, 10, and 20 gallons per acre on two sites off the experimental range were also reported.

338. Roach, Mack E.; Glendening, George E. 1956. Response of velvet mesquite in southern Arizona to airplane spraying with 2,4,5-T. Journal of Range Management. 9(2): 70-73.

The effects of airplane spraying with several formulations of 2,4,5-T on velvet mesquite were tested. The chemicals were applied in different concentrations and carriers. (Refer to Roach and Glendening 1954.)

339. Rodgers, Kenneth J.; Ffolliott, Peter F.; Patton, David R. 1978. Home range and movement of five mule deer in a semidesert grass-shrub community. Research Note RM-355. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 6 p.

The home ranges of five desert mule deer (*Odocoileus hemionus crooki*) were determined on SRER between May 1975 and June 1976. Home range averaged 2.9 square miles but varied for individual deer by season, sex, and age class. The area of activity within the home range was smallest during the spring and early summer and largest during the winter breeding season. The collared deer were found to be nonmigratory and restricted to the SRER. Seasonal movements were within the home range. Minimum movement between consecutive days was approximately one-half mile in the spring and summer. Breeding season activity and disturbances by humans altered the normal movement patterns.

340. Rodgers, Kenneth Joseph. 1977. Seasonal movement of mule deer on the Santa Rita Experimental Range. Tucson, AZ: University of Arizona. 63 p. M.S. thesis.

Home ranges averaged 2.9 square miles but varied from 1.5 to 4.8 square miles depending on season, sex, and age class. Availability of permanent water was found to be a primary determinant of home range size. Mule deer were essentially nonmigratory. Deer activities changed seasonally and with local weather condition but were normally confined to their home range with the exception of the rut. Cattle presence and vegetation-soil associations had no noticeable effect on habitat use patterns. Mesquite-lined washes provided preferred cover for deer year-round. Social aggregations centered around the family unit.

341. Russell, S.; Smith, E.; Gould, P.; Austin, G. 1972. Studies on Sonoran birds. US/IBP Desert Biome 1971 Progress Report. Logan, UT: Ecology Center, Utah State University. 13 p.

Density of birds varied during the year from 59-119 birds/100 acres. This includes a total of 40 species being on the site sometime during the year. Biomass varied from 3136-7673 g/100 acres. Reproductive success was low in 1971, except for hole-nesting species. The dry spring, originally thought to cause this success depression, may not be the factor involved. During the rainy season the success depression continued, thus eliminating a drought-reproductive success correlation.

342. Russell, S. M.; Gould, P. J. 1974. Population structure, foraging behavior and daily movements of certain Sonoran Desert birds. US/IBP Desert Biome Research Memorandum 74-27. Logan, UT: Ecology Center, Utah State University. 7 p.

On the Silverbell site, nesting in 1973 began later in the spring and terminated earlier in the summer than in 1972. But in 1973 more pairs held territories, built nests, laid eggs, hatched young, and fledged young. The biomass of young fledged in 1973 was over three times the biomass produced in 1972. Fifty-three percent of the nests built fledged young. Predation was again the largest cause of nest failure. Estimates of the wet weight of foods consumed by plot birds are included. The presence of *Carnegiea gigantea* is responsible for an estimated 28-35% of the wet weight biomass of site birds.

343. Russell, S. M.; Gould, P. J.; Smith, E. L. 1973. Population structure, foraging behavior and daily movements of certain Sonoran Desert birds. US/IBP Desert Biome Research Memorandum 73-27. Logan, UT: Ecology Center, Utah State University. 20 p.

Birds nested from February to September; on the Silverbell site about 70% of all nests constructed were begun before the onset of summer rains, but some species did not nest before the rains began. An adult breeding population of 7.5 kg (22 species) on a 20 ha plot of the Silverbell site produced a fledgling biomass of 4.6 kg; 41% of all nests that contained at least one egg fledged young and 32% of all eggs laid produced fledglings. Nesting failures were due primarily to predation (37%) and cowbird parasitism (22%). On the SRER 20-ha plot, 15 species nested after June 15, 39% of all eggs laid produced fledglings, and a total fledgling biomass of 3.3 kg resulted. Fledging success was highest in late July and August and coincided with peak insect abundance. It does not appear that the drought in the first 5 months of 1972 had an adverse effect on nesting success. Wintering sparrows consumed mostly seeds of *Aristida, Panicum* and *Paspalum.*

344. **Rutledge, James Thomas. 1984. A shallow seismic refraction survey over a late quaternary fault scarp west ofthe Santa Rita Mountains, Arizona. Tucson, AZ: Department of Geosciences, University of Arizona. 93 p. M.S. thesis.**

A 3,300-foot seismic refraction profile was shot perpendicular to a fault scarp west of the Santa Rita Mountains. This study was undertaken to infer faulting history by delineating subsurface structure. A suballuvial bedrock pediment surface and a shallower alluvial horizon were mapped in profile using the generalized reciprocal method of refraction interpretation. The bedrock shows a minimum normal offset of 50 feet at an approximate depth of 500 feet. The alluvial horizon shows a normal offset of 10 feet at an approximate depth of 70 feet. These offsets indicate 40-65 feet of fault displacement occurred between burial of the bedrock pediment surface and deposition of the shallow alluvial horizon.

345. **Ruyle, G. B.; Abu-Zanat, M.; Rice, R. W. 1988. The influence of grazed patches on cattle foraging behavior. Proceedings American Society of Animal Science. 39: 234-236.**

This study characterized available herbage and cattle grazing behavior in heavily grazed patches and lightly grazed areas on rangeland dominated by Lehmann's lovegrass. Cow biting rates were lowest on previously ungrazed plants and highest on plants found in heavily grazed patches. During the active plant growing seasons biting rates were higher than the dry seasons but remained low in lightly grazed areas.

346. **Ruyle, G. B.; Hasson, Oren; Rice, R. W. 1987. The influence of residual stems on the biting rates of cattle grazing *Eragrostis lehmanniana* Nees. Applied Animal Behavior Science 19:11-17.**

This study characterized the biting behavior of cattle on heavily lightly grazed areas. Biting rates and handling times were affected by the presence and heights of residual stems in each plant encountered by grazing cattle. Handling times were nearly 0.5 seconds longer for bites taken on plants containing residual stems than bites taken on previously grazed plants where residual stems were absent.

347. **Ruyle, G. B.; Ogden, P. R.; Rice, R. W. 1988. Defoliation patterns of cattle grazing Lehmann lovegrass (*Eragrostis lehmanniana* Nees). Applied Agricultural Research. 4: 177-181.**

This study investigated defoliation patterns on individual lehmann lovegrass tillers in pastures grazed yearlong by cattle at four stocking rates (1.8, 2.4, 2.6, and 4.1 animal unit months/ha). Regardless of stocking rates, cattle grazing patterns created uneven utilization of lehmann lovegrass, maintaining patchy areas of heavy use. Grazing frequency and intensity were measured weekly for 2 years on marked tillers in and between heavily grazed patches. Tillers were grazed in all months with use increasing during the summer growing season. Throughout both years. over 75% of the grazing events occurred in the previously grazed patches in all pastures. While only 18% of the grazed tillers were defoliated more than once, the vast majority of repeatedly grazed tillers (90%) occurred in grazed patches. At each grazing, an average of 72% of tiller biomass was removed regardless of stocking rate. Recommended stocking levels appear to be around 2.5 animal unit month/ha.

348. **Ruyle, George. 1985. Managing Lehmann lovegrass for livestock. Arizona Farmer Stockman. 51(5): 46.**

Current management practices include using high animal densities in a rotational scheme and grazing in the winter and spring. Merely changing livestock numbers doesn't appear to substantially alter cattle grazing patterns on lehmann lovegrass pastures.

349. **Ruyle, George; Cox, Jerry. 1985. Lehmann lovegrass--a naturalized citizen. Arizona Farmer Stockman. 51(4): 26.**

Lehmann lovegrass has spread considerably in southern Arizona, owing to the plant's aggressive establishment. It thrives best at elevations between 500 and 3000 feet, where annual rainfall is between 10 and 14 inches. It prefers sandy to sandy-loam soils.

350. **Sammis, Theodore Wallace. 1972. Channel transmission losses in small watersheds. Tucson, AZ: Department of Hydrology and Water Resources, University of Arizona. 57 p. M.S. thesis.**

The relationship of water infiltration into stream channel bed to texture, structure, and moisture content of the alluvium deposits and deposition of such water are investigated. The infiltration equation developed by Philip is used. The coefficients are estimated using data from an infiltration simulator and a double ring infiltrometer. A linear relationship between the absorptivity coefficient in the equation and the initial soil moisture is provided as are relationships between evapotranspiration rates and potential rates as measured empirically.

351. **Sammis, Theodore Wallace. 1974. The microenvironment of a desert hackberry plant (*Celtis pallida*). Tucson, AZ: Department of Hydrology and Water Resources, University of Arizona. 171 p. Ph.D. dissertation.**

Evapotranspiration rates of plots with vegetative cover and evaporation rates from bare soil differed during the active growing season, but total water losses from both plots were the same. A model using soil and plant parameters predicted evapotranspiration rates during the active growing season when water was not limiting but was unreliable when plants were under stress. Plant diffusion resistance appeared to increase linearly with decreasing soil moisture until it reached a critical value, below which it rose sharply.

352. Schmidt-Nielsen, Bodil; Schmidt-Nielsen, Knut. 1950a. Evaporative water loss in desert rodents in their natural habitat. Ecology. 31(1): 75-85.

It was found that the humidity inside the burrows always is considerably higher than outside. If the animals were breathing the air outside the burrows with its very low moisture content, the rate of evaporation from the lungs would exceed the rate of formation of metabolic water, with the result that the animals would lose water by their metabolism. By calculations, it is shown that the higher humidity in the burrows is very significant for the water balance of the animals. The formation of metabolic water will, when the animals breathe the fairly moist air in the burrows, lead to an ultimate gain in water.

353. Schmidt-Nielsen, Bodil; Schmidt-Nielsen, Knut. 1950b. Pulmonary water loss in desert rodents. The American Journal of Physiology. 162(1): 31-36.

The evaporation from the lungs of humans is about 0.84 mg H_2O/ml 0_2 taken up in the lungs, when dry air is inspired. In white rats and mice the evaporation from the total animal was found to be of the same order. This could be anticipated because these animals probably have a minimum of evaporation through the skin, and the lungs account for the larger part of the evaporation. In desert rodents as well as in hamsters and wild mice, the total evaporation was around 0.5 mg H_20/ml 0_2 utilized. This considerable reduction in pulmonary evaporation is of great importance to the desert rodents in their water balance. The mechanism is not clear, but might be found in a higher utilization of alveolar oxygen or in a reduced water content of the expired air.

354. Schmidt-Nielsen, Bodil; Schmidt-Nielsen, Knut. 1951. A complete account of the water metabolism in kangaroo ratsand an experimental verification. Journal of Cellular and Comparative Physiology. 38(2): 165-181.

The account shows that kangaroo rats are in positive water balance when given a diet of dry pearled barley without drinking water at all atmospheric humidities above 2.2 mg H_20/liter air (10% rel. hum. 25°C.). Kangaroo rats were kept at various atmospheric humidities and their weight changes were registered. The animals could not maintain body weight below about 2.5 mg H_20/liter air, but above this limit they maintained or gained body weight. The water output in white rats is considerably higher than in kangaroo rats and according to the calculations, they are in negative water balance at all atmospheric humidities below around 21 mg H_20/liter air. White rats and hamsters kept at atmospheric humidities around 21 mg H_20/liter of air were not able to maintain body weight but lost weight rapidly.

355. Schmidt-Nielsen, Bodil; Schmidt-Nielsen, Knut; Brokaw, Adelaide; Schneiderman, Howard. 1948. Water conservation in desert rodents. Journal of Cellular and Comparative Physiology. 32(3): 331-360.

Certain desert rodents can survive for any length of time on dry food only (grain) without any water. These animals do not have any storage of water that is of importance to their survival. They are able to reduce the urinary water loss greatly by excreting a highly concentrated urine. This takes place under natural conditions as well as under experimental conditions.

356. Schmidt-Nielsen, Knut; Dawson, T. J.; Hammel, H. T.; Hinds, David; Jackson, Donald C. 1966. The jack rabbit--a study in its desert survival. Hvalra;dets Skrifter. 48: 125-142.

The results showed that evaporation of water is essential for the maintenance of safe body temperatures during heat load. The heat load, and therefore the use of water, is reduced by seeking shade. Other factors that contribute to reducing the water loss are the insulation and reflectivity of the fur. Use of the clear sky as a radiation heat sink is not possible during the hottest part of the day, but in the mid-afternoon when solar and reflected radiation are reduced, this becomes possible, even when the air temperature remains high. The blood flow in the ears is high when conditions permit heat loss, but when the net heat flux is unfavorable to the animals there is immediate vasoconstriction in these large surfaces so that heat gain is minimized. Also a relatively high lethal temperature provides a possible safety factor in marginal situations.

357. Schmidt-Nielsen, Knut, Schmidt-Nielsen, Bodil; Brokaw, Adelaide. 1948. Urea excretion in desert rodents exposed to high protein diets. Journal of Cellular and Comparative Physiology. 32(3): 361-379.

A maximum load on the excretory system was imposed by giving the animals a dry diet rich in protein (beans). It was found that rodents of the Heteromyid family can excrete urea in concentrations over 3.6 M (22%), while the concentration limit for the rat is about 2.5 M (15%) and humans about 1 M (6%). Electrolytes were also excreted in very high concentrations (up to nearly 1.2 N). These concentrations in the Heteromyid group are about twice the maximum excretory ability known for other mammals. Another desert rodent, the *Neotoma*, which cannot survive on exclusively dry food, has solved the water problem by the consumption of succulent food (cactus). The maximum urea concentration in the urine during nitrogen load was 2 M (12%), i.e., for excretion of urea this species expends nearly twice as much water as the Heteromyid rodents. The significance of an excretory system with record excretory power is that it enables the desert animals to maintain water balance.

358. Schmidt-Nielsen, Knut; Schmidt-Nielsen, Bodil; Schneiderman, Howard. 1948. Salt excretion in

desert mammals. The American Journal of Physiology. 154(1): 163-166.

Some desert rodents excrete a very concentrated urine, which enables them to expend only small amounts of water for excretion. The maximum excretory ability with respect to electrolytes is about 1,200 mN, and for chlorides about 900 mN. This appears to be far in excess of the limits known from other mammals. This ability must be interpreted as a very useful mechanism for water conservation and an adaptation to desert life.

359. Schrader, F. C.; Hill, J. M. 1909. Some occurrences of molybdenite in the Santa Rita and Patagonia Mountains, Arizona. *In:* Contributions to Economic Geology Bulletin 430. Washington, DC: U.S. Department of the Interior, Geological Survey: 154-163.

The geology and mineral deposits of the Ridley Mine located on SRER are described.

360. Schrader, Frank C. 1915. Mineral deposits of the Santa Rita and Patagonia Mountains, Arizona. *In:* Bulletin 582. Washington, DC: U.S. Department of the Interior, Geological Survey: 126-127.

The mineral deposits and general geology of the Ridley Mine located on SRER are briefly described.

361. Severson, Keith E.; Medina, Alvin L. 1981. The Santa Rita Experimental Range. *In:* Patton et al., tech. coords. Wildlife and range research needs in northern Mexico and southwestern United States. General Technical Report WO-36. Washington, DC: U.S. Department of Agriculture, Forest Service: 56-59.

Research emphasis on SRER supports range livestock production on semidesert grasslands. This paper describes the range, the background of information currently available, future research direction, and possibilities for cooperative studies.

362. Short, Henry L. 1979. Food habits of coyotes in a semidesert grass-shrub habitat. Research Note RM-364. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 4 p.

Coyotes (*Canis latrans*) feeding in a semidesert grass-shrub habitat consume a variety of foodstuffs throughout the year. The relative incidence of several plant and animal items in coyote scat did not seem to vary throughout the year. The incidence of other items, like pocket mice (*Perognathus* spp.) in late winter and spring, bird eggs in early summer, and the fruits of prickly pear (*Opuntia engelmannii*) and mesquite (*Prosopis juliflora*) in late summer, varied in an interpretable manner between months.

363. Shumway, R. Phil; Hubbert, Farris, Jr.; Hayer, W. T., III; Cable, D. R.; Hale, W. H. 1963. A qualitative determination of the diet of grazing steers under desert grassland conditions. Proceedings of Western Section American Society of Animal Science; Corvallis, Oregon; 1963 August. 14(38): 1-6.

The average protein content of the main perennial grasses is related to the protein content of the diet selected by the grazing steer. An increase of 1.79% crude protein in the rumen sample for each 1% increase in the protein content of perennial grasses represents the selectivity exerted by the grazing steer. Alfalfa hay trials showed a slight decrease in crude protein content from feed to rumen samples taken 30 minutes after feeding.

364. Simanton, J. R.; Dixon, R. M.; McGowan, I. 1978. A microroughness meter for evaluating rainwater infiltration. Proceedings of the 1978 Joint Annual Meeting of the

Hydrology and Water Resources in Arizona and the Southwest, American Water Resources Association, Arizona Section-Arizona Academy of Science, Hydrology Section; 8: 171-174.

The microroughness meter is a convenient, quick, simple, and accurate means of measuring surface roughness. The number of points taken/1-m^2 plot, the rapid means of data recording and analysis, and the simple method of lowering and lifting of the 100 measuring pins make the meter very useful for studies requiring many plots and data points. The meter was very accurate in repeating the same surface roughness measurements, but it was not precise in defining the theoretical characteristics of constructed surfaces. However, these errors in precision were insignificant and due partly to surface geometry construction errors. The roughness meter is presently being used to monitor surface changes produced during range improvement treatments. Regular measurements made of permanent transects in surface roughened areas are being used to define the longevity of the roughness and changes in surface characteristics.

365. Slayback, Robert D.; Cable, Dwight R. 1970. Larger pits aid reseeding of semidesert rangeland. Journal of Range Management. 23(5): 333-335.

Broad, shallow intermediate pits have proved to be longer lasting than conventional pits on semidesert range in the 6- to 8-inch summer rainfall zone in southern Arizona. Rainfall penetration averaged twice as deep in the pits as on adjacent flats. Herbage production of buffalo-grass averaged 2½ times more, over a 4-year period, on the intermediate pits than on conventional pits, and five times more than on similar adjacent untreated range.

366. Stevenson, Ellerslie W. 1940. A study of organic food reserves in burroweed (*Applopappus fruticosus*) through the flowering period. Tucson, AZ: University of Arizona. 40 p. M.S. thesis.

Root and stem fractions were analyzed for reducing sugars, sucrose, starch, total nitrogen, and moisture. Moisture content varied in the roots, root crowns, and older stems with the amount of soil moisture available to the plant. Moisture in stem tips increased rapidly after the first rains and continued until maturation. Reducing sugars and sucrose tended to increase gradually in all fractions of the plant toward the latter part of the flowering period.

367. Streetman, L. J. 1959. Study of the chromosome number, microsporogenesis, megasporogenesis, embryo sac development, and embryogeny in black grama grass, *Bouteloua eriopoda* (Torr.) Torr. Tucson, AZ: Department of Agronomy, University of Arizona. 45 p. Ph.D. dissertation.

Root tips were found to be unsatisfactory for somatic chromosome counts. Meiotic behavior of diploid plants was normal. Aneuploid plants with 28 chromosomes were found at one location and most plants were sterile. Meiotic chromosome counts could not be made from megaspore mother cells. The number of antipodals never exceeded three as reported in other grasses. Individual plant variation within and among accessions furnished evidence for sexual reproduction and that the species was largely cross pollinated.

368. Subirge, Thomas Guenter. 1983. Soil-plant relations on the Santa Rita Experimental Range, Arizona. Tucson, AZ: Department of Soil, Water and Engineering, University of Arizona. 165 p. M.S. thesis.

This study evaluated the soil characteristics that control or influence the production and composition of the native vegetation. The data were obtained from 80 vegetation transects for which production and intercept data were available for a 10-year period between 1957 and 1966. Information about the soils was collected in 1977. Range sites were defined based on their vegetative and soil characteristics. The main site characteristics found to be influencing the vegetation were rock cover and content on the subsoil, subsoil clay content, and slope.

369. Swarth, Harry S. 1929. The faunal areas of southern Arizona: A study in animal distribution. Proceedings of the California Academy of Sciences Fourth Series. XVIII(12): 267-383.

Specimens of bird and small mammals were collected on the lowlands surrounding the Santa Rita Mountains. Other data include distribution maps, climatic data, vegetation and historical accounts of rangeland uses.

370. Tanbal, Khalid Mohamed. 1987. A gravity survey over late Quaternary fault scarps west of the Santa Rita Mountains, Arizona. Tucson, AZ: Department of Geosciences, University of Arizona. 55 p. M.S. thesis.

This study reports on gravitational determinations on various sites on SRER.

371. Tapia Jasso, Carlos. 1965. Root nodule studies of a desert browse legume guajilla (*Calliandra eriophylla* Benth.). Tucson, AZ: University of Arizona. 51 p. M.S. thesis.

Investigations confirmed the presence of nodules and suggested that the Rhizobium responsible was nitrogen active. It was suggested that only the mesquite-grassland and oak-woodland communities of the Sonoran Desert shrub region have sufficient numbers of the species to warrant consideration as a nitrogen supply in range and watershed proposals.

372. Taylor, Walter P. 1930. Methods of determining rodent pressure on the range. Ecology. 11(3): 523-542.

Methods of determining rodent pressure include counts of rodents actually seen per unit area, trapping, the poison bait spot count, the den count, acre list count, rodent cross-section, rodent pellet counts, and measurement of rodent effects on vegetation. Methods of determining the true significance of rodent pressure on the soil are lacking.

373. Taylor, Walter P. 1935. Some animal relations to soils. Ecology. 16(2): 127-135.

Animals affect soils by: (1) the accumulation of excreta and deposition of body parts; (2) the accumulation on or in soils of materials for houses, shelters, and foods; (3) the pounding of the surface; (4) burrowing; (5) improving the water-holding capacity through natural cultivation; (6) cycling earth to the surface; (7) contributing to the deepening of soils; and (8) incorporation of nitrogenous material.

374. Taylor, Walter P.; Vorhies, Charles T. 1923. Kangaroo rats and scorpion mice on the Santa Rita Reserve, Arizona. Journal of Mammalogy. 4(4): 255.

A pair of kangaroo rats were captured on each of two mounds. *Onychomys* apparently drove out the *Peromyscus* on a site.

375. Taylor, Walter P.; Vorhies, Charles T.; Lister, P. B. 1935. The relation of jack rabbits to grazing in southern Arizona. Journal of Forestry. 33(5): 490-498.

Jackrabbits feed on valuable range vegetation. A preference was found for areas on which livestock grazing had reduced the vegetative stand, provided a moderate forage supply was available. Similarly, a much greater insect population has been found on overgrazed than on lightly grazed range in Oklahoma. Earlier investigators have traced relationships between vegetative depletion by livestock and a multiplication of grasshoppers and white grubs, and have noted increases of certain small mammals following the disturbance of the native prairies of the Middle West. The results of altered character of plant cover are expressed in terms not only of plant succession but also of animal succession; the associative complex is not merely botanical but is also zoological and therefore inclusively biological. Increases of insects and certain vegetation-consuming mammals may be an effect of vegetative depletion rather than primarily a cause, or may be both an effect and in turn a cause. Maintaining range use and range vegetation in the right balance may be a problem into which should be integrated the control of animal life through the kind and amount of vegetation. For foresters already accustomed to thinking of the forest as a biological complex comprising the animal as well as the plant life of the area, new vistas are brought into view by this highly suggestive paper relating to the range.

376. Thames, John; Qashu, H.; Kiesel, C. 1971. Development of a technique for measuring the water balance of validation study areas. US/IBP Desert Biome 1970 Progress Report. Logan, UT: Ecology Center, Utah State University. 16 p.

An investigation of methods for assessing the water balance of a validation site by sampling rainfall, soil moisture, and stream flow. Although results from the first year cover only a very limited range of moisture conditions because of a continuing drought, some interesting problems in sampling statistics have been pointed up that show a potential for greatly reducing work in estimating soil water over extensive areas.

377. Thornber, J. J. 1910. The grazing ranges of Arizona. Bulletin No. 65. Tucson, AZ: University of Arizona, Agricultural Experiment Station. 360 p.

This historical account presents information on: (1) the amount and seasonal distribution of rainfall and its relation to forage production; (2) the effects of prolonged droughts on the plant cover, especially in connection with overgrazing; (3) the viability of seeds of forage plants, with factors affecting germination; (4) the seasonal production of forage of the various groups of native forage plants; (5) the conditions of primitive or little-grazed ranges; (6) the rate of recovery under protection of the various types of ranges; (7) the carrying capacity of different classes of ranges; (8) the value of storm water embankments and of simple cultural operations; and (9) the proper administration of grazing ranges.

378. Thornber, J. J. 1911. Native cacti as emergency forage plants. *In:* Bulletin 67. Tucson, AZ: University of Arizona, Agricultural Experiment Station: 457-508.

Native cacti species were examined for forage quality and to determine the economic feasibility of growing them in sufficient quantity on the lower mesas or desert ranges to provide dependable forage supplies for stock during prolonged drought. Results of cultural work with cacti are discussed and suggestions made on propagation.

379. Tiedemann, Arthur R.; Klemmedson, James O. 1973a. Effect of mesquite on physical and chemical properties of the soil. Journal of Range Management. 26(1): 27-29.

Soil under the crown of mesquite trees was compared to soil from adjacent openings at three depths for several physical and chemical properties. Bulk density was lower in soil under mesquite but increased with depth in that location. Organic matter, total nitrogen, total sulfur, and total soluble salts were up to three times greater in the surface 0 to 4.5 cm of mesquite soil than in open soil but declined with increasing depth to levels approximately the same as in open soil. Total potassium was higher under mesquite but increased with depth. Total phosphorus and hydrogen ion concentrations were the same in soil under mesquite as in soil from open areas.

Results suggest that mesquite trees function to improve soil conditions under their canopies by redistributing nutrient ions from areas beyond the canopy to areas beneath the canopy. This process helps to explain the greater abundance and improved growth of perennial grasses observed under mesquite. It also helps to explain grazing patterns and responses on desert grassland.

380. Tiedemann, Arthur R.; Klemmedson, James O. 1973b. Nutrient availability in desert grassland soils under mesquite (*Prosopis juliflora*) trees and adjacent open areas. Soil Science of America Proceedings. 37(1): 107-110.

A pot-culture technique was used to calculate relative yields for N, P, K, and S as an index of availability of these nutrients in soil from under mesquite (*Prosopis juliflora* (Swartz.) DC) trees and from adjacent open areas on a desert grassland site. Arizona cottontop (*Trichachne californica* (Benth.) Chase), plains bristlegrass (*Setaria macrostachya* H.B.K.), and bush muhly (*Muhlenbergia porteri* Scribn.), all native perennial grasses that grow abundantly under mesquite, were used as test plants. Relative yields for N were up to 15 times higher in soil under mesquite trees than in nonmesquite soil, whereas the level of total N was only 3 times greater. The soil under mesquite trees apparently provides a more favorable environment for supply of N than nonmesquite soil. Relative yields for S in mesquite soil were three times greater than in nonmesquite soil and were proportional to the difference in total S between soils, indicating that S is supplied more slowly than N under mesquite trees. Phosphorus showed a slight, although significant, difference in availability between soils, but total P was the same in the two soils. A threefold-higher level of organic matter in soil under mesquite probably contributes to increased availability of P. Differences in total potassium and its supply to test plants were not detected between the two soils.

381. Tiedemann, Arthur R.; Klemmedson, James O.; Ogden, Phil R. 1971. Response of four perennial southwestern grasses to shade. Journal of Range Management. 24(6): 442-447.

A nursery plot study was conducted to determine if the observed relative abundance of Arizona cottontop, bush muhly, and plains bristlegrass under mesquite trees on native range was related to the ability of these grasses to adapt to shade. Plants of these species, plus black grama which grows in open areas, were subjected to shading only and shading after defoliation treatments using five levels of shade from 0 to 80%. Evaluation of morphological, physiological, and yield responses showed that all plants made their best growth in full sunlight; but Arizona cottontop, bush muhly, and plains bristlegrass displayed greater ability than black grama to adapt to shade.

382. Tiedemann, Arthur Ralph. 1970. Effect of mesquite (*Prosopis juliflora*) trees on herbaceous vegetation and soils in the desert grassland. Tucson, AZ: Department of Watershed Management, University of Arizona. 159 p. Ph.D. dissertation.

Prior to treatment, crown cover of perennial grasses was greater under mesquite canopies (24%) than in open areas (4%). Crown cover of forbs and annual grasses was increased by eliminating moisture use by mesquite (no shade treatment), but there was no additional increase when shade was replaced. Perennial grasses did not respond to the no shade treatment, but they increased sharply with the artificial shade treatment. Only forbs responded to shade treatment. Responses of understory vegetation indicated that microenvironmental conditions were improved with the no shade and artificial shade treatments, but no increase in soil moisture was detected on or off the plot.

383. Tixier, J. S. 1959. Effects of ammonium phosphate on a southern Arizona desert grassland range. Tucson, AZ: University of Arizona. 20 p. M.S. thesis.

Arizona cottontop responded in height growth to fertilization at rates of 200 and 400 pounds/acre, with plants in the 200 pound treatment averaging almost half as much as those on the check plots. Lehmann lovegrass showed no height growth response. Forage production of lehmann lovegrass increased at only 200 pound treatment levels; Arizona cottontop increased at both levels.

384. Trapp, Richard A. 1987. Geochemistry of the Laramide igneous suite of the Santa Rita and Empire Mountains, Southeastern Arizona. Tucson, AZ: Department of Geosciences, University of Arizona. 118 p. M.S. thesis.

Instrumental neutron activation analysis was used to determine degree of relatedness between four geological substrates. The Sierrita Mountains contain world-class porphyry copper deposits while the Santa Rita and Empire Mountains, 20 miles to the east, have relatively meager metal production.

385. Tschirley, Fred H. 1959. Effect of mesquite on range productivity. *In:* Your range--its management. Special Report No. 2. Tucson, AZ: University of Arizona, Agricultural Experiment Station: 17.

Controlling mesquite resulted in increased forage production and an increased number of better forage species.

386. Tschirley, Fred H. 1963. A physio-ecological study of jumping cholla (*Opuntia fulgida* Engelm.). Tucson, AZ: Department of Watershed Management, University of Arizona. 100 p. Ph.D. dissertation.

Several aspects dealing with the ecology of cholla are discussed, including reproduction, germination, development, life history and population dynamics.

387. Tschirley, Fred H.; Hull, Herbert M. 1959. Susceptibility of velvet mesquite to an amine and an ester of 2,4,5-T as related to various biological and meteorological factors. Weeds. 7(4): 427-435.

An ester and an amine of 2,4,5-T were tested at frequent intervals from April 29 to July 1, 1955, on velvet mesquite. The ester of 2,4,5-T was consistently more effective than the amine under the conditions of this experiment, and its period of maximum effectiveness was longer. In addition, the difference in effectiveness between the ester and the amine salt increased as the season progressed. The optimum growth stage for application of the ester is defined as that time when leaves are full size but still succulent, flower development is complete, and pods have started developing.

388. Tschirley, Fred H.; Martin, S. Clark. 1960. Germination and longevity of velvet mesquite seed in soil. Journal of Range Management. 13(2): 94-97.

Seeds of velvet mesquite were still able to germinate after 10 years in the soil. Germination of hulled seeds was 15.8%; of seeds in pods, 44.7%.

389. Tschirley, Fred H.; Martin, S. Clark. 1961. Burroweed on southern Arizona rangelands. Technical Bulletin 146. Tucson, AZ: University of Arizona, Agricultural Experiment Station. 34 p.

A brief summary of what is known about burroweed (*Haplopappus tenuisectus* (Greene) Blake) from observations and research conducted in southern Arizona over a period of almost 60 years. The discussion includes taxonomy, life history, geographic distribution, relationship to cattle grazing, chemical composition, and methods of control. The results of 98 different herbicide treatments are listed in the appendix.

390. Tschirley, Fred H.; Wagle, R. F. 1964. Growth rate and population dynamics of jumping cholla (*Opuntia fulgida* Engelm.). Journal of the Arizona Academy of Science. 3(2): 67-71.

Mean annual growth over a 12-year period was 0.67 inch. Small plants grew at a rate of about 3 inches per year, while large plants decreased their rate of growth in height. Populations may be classified as invading, mature, or senescent depending on distribution of size classes. *Edwinea carnegieana* was suspected to be the cause of rapid die-offs.

391. Tucker, T. C.; Westerman, R. L. 1972. Gaseous losses of nitrogen from the soil of semiarid regions. US/IBP Desert Biome 1971 Progress Report. Logan, UT: Ecology Center, Utah State University. 11 p.

The potential for gaseous loss of nitrogen from desert soils was demonstrated. The amount of gaseous loss was influenced greatly by the amount of initial soil organic matter and additions of glucose as an energy source. Complete reduction of NO_3 to N_2 required an adequate source of energy, either organic matter or glucose addition. Reduction of NO_3 to N_20 occurred with a less available energy source as indicated by the evolution of N_20 at lower profile depths. The gaseous loss of added NO_3 ranged from 23% to 56%, without glucose, and from 41% to 67% with glucose incubated for 18 days under an argon atmosphere.

392. Tucker, T. C.; Westerman, R. L. 1973. Gaseous losses of nitrogen from the soil of semi-arid regions. US/IBP Desert Biome Research Memorandum 73-37. Logan, UT: Ecology Center, Utah State University. 15 p.

The potential for gaseous loss of N was observed in all soils at all depths and resulted in $15N_2$ and $15N_20$ evolution. The calculated loss in 18 days of added $15N0_3$ ranged from approximately one-tenth to more than two-thirds of the total amendment. An organic carbon energy source was included in portions of these studies. Glucose additions increased N in the gaseous phase and increased the calculated loss based on 15N remaining in the soil after incubation. Oxygen consumption increased, indicating biological and/or chemical activity, when the soils were moistened. Although oxygen was consumed in soils from all profile depths within 24 hr, the rate of consumption was higher in the surface soils of all profiles except the one having the buried A horizon. The number of denitrifying organisms under saturated moisture increased with soil depth, incubation time, and additions of NO_3-N and organic carbon.

393. Tucker, T. C.; Westerman, R. L. 1974. Gaseous losses of nitrogen from the soil of semiarid regions. US/IBP Desert Biome Research Memorandum 74-39. Logan, UT: Ecology Center, Utah State University. 11 p.

Preliminary results indicate some losses of nitrate occurred during incubation under sterile conditions. The effects of organic carbon, moisture, temperature, soil depth, and time on denitrification were investigated. Overall nitrate losses from the system were more than doubled by the addition of glucose. Approximately 1.5 times as much nitrate was lost at 37°C as at 20°C. Saturated moisture conditions increased nitrate loss over moisture at field capacity but to a smaller degree. Soil depth was not a significant factor in nitrate loss. Increasing the incubation time increased overall loss from 23% at 5 days to 26% and 30% at 10 and 15 days, respectively. The addition of organic C increased the amount of added N found in the soil organic N fraction. Without organic C addition most of the 15N remaining was in nitrate form. Soil respiration was increased at two Santa Rita sites by amendments of N, organic C or the combination. Ammonium volatilization losses were not detected. Laboratory studies showed that C:N ratio may be an important factor influencing denitrification. At high C:N ratios (>45:1) increased immobilization may prevent excessive denitrification.

394. Turkowski, Frank J.; Vahle, J. Robert. 1977. Desert rodent abundance in southern Arizona in relation to rainfall. Research Note RM-346. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 4 p.

Desert rodent populations in southern Arizona fluctuated in numbers and species composition over a 30-year period. Data indicate that the direction of these annual fluctuations can be predicted from the amount of rainfall received during the previous year.

395. Upson, Arthur. 1937. Does extra rainfall always make more grass? Research Note 11. Tucson, AZ: U.S. Department of Agriculture, Forest Service, Southwestern Forest and Range Experiment Station. 3 p.

Tests on three native grasses (black grama, Rothrock grama, and threeawn) showed different responses to rainfall distribution throughout the year. Variations in July rainfall have only little effect on the growth of the gramas the following year, but late summer rains benefit both gramas next year. Above-average rainfall during the winter season may decrease growth the following season in Rothrock grama. The benefits from extra spring precipitation decrease until middle summer, when there is practically no benefit. Threeawn responded differently than gramas.

396. U.S. Department of Agriculture. 1925. Santa Rita Range Reserve, range tour report. [Originally presented at Field Day Activities, October 3, 1925.] Tucson, AZ: U.S. Department of Agriculture, Forest Service, Southwestern Forest and Range Experiment Station. 20 p.

Describes the nature of research activities on SRER, including improvement of the type and grade of cattle, increasing of calf crops, economic considerations, range

improvement, range carrying capacities, and rodent-livestock-range interactions.

397. **U.S. Department of Agriculture. 1927. Santa Rita Range Reserve, range tour report, [Originally presented at Field Day Activities, April 5-9, 1927.] Tucson, AZ: U.S. Department of Agriculture, Forest Service, Southwestern Forest and Range Experiment Station. 20 p.**

Describes the nature and progress of investigations dealing with management of range resources and management of livestock.

398. **U.S. Department of Agriculture. 1937a. Does extra rainfall always make more grass? Research Note 11. Tucson, AZ: U.S. Department of Agriculture, Forest Service, Southwestern Forest and Range Experiment Station. 3 p.**

Semidesert ranges that are made up of black grama and Rothrock's grama will be best when there are relatively wet falls and springs, with dry winters in between. Rainy or snowy winters will not necessarily mean better grama grass. Three-awned grasses are not vitally affected by alternating wet and dry weather.

399. **U.S. Department of Agriculture. 1937b. An economic study of cattle business on a southwestern semidesert range. Research Note 4. Tucson, AZ: U.S. Department of Agriculture, Forest Service, Southwestern Forest and Range Experiment Station. 2 p.**

Results of an 11-year study of the cattle breeding business are reported. Factors affecting economics are presented and discussed.

400. **U.S. Department of Agriculture. 1952. The Santa Rita Experimental Range. Booklet (revised). Tucson, AZ: U.S. Department of Agriculture, Forest Service, Southwestern Forest and Range Experiment Station. 17 p.**

Three major research projects--grazing management, noxious plant control, and artificial range reseeding--are described. Preliminary findings regarding production, management, and economic returns are discussed.

401. **U.S. Department of Agriculture. 1957. Range day: Santa Rita Experimental Range. Tempe, AZ: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 32 p.**

Ten research papers dealing with investigations on SRER are presented.

402. **U.S. Department of Agriculture. (No date). Santa Rita Experimental Range: Aerial mesquite control. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 2 p.**

Results indicate that 1/3 pound per acre of low-volatile ester of 2,4,5-T applied in 4 gallons of 1:7 diesel oil: water emulsion applied twice either 1 or 2 years apart is reasonably effective.

403. **U.S. Department of Agriculture. (No date). Santa Rita Experimental Range: Burroweed invasion. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 2 p.**

Results show that burroweed is a fluctuating component of semidesert vegetation. On some areas, burroweed can serve a useful purpose by providing protection from grazing and germination site for perennial grasses.

404. **U.S. Department of Agriculture. (No date). Santa Rita Experimental Range: Changes in jumping cholla. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 1 p.**

In some areas, cholla was widely spaced in 1905, grew to a dense stand around 1940, and decreased to a scattered stand by 1962. The causes for these changes are uncertain.

405. **U.S. Department of Agriculture. (No date). Santa Rita Experimental Range: Controlling jumping cholla. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 1 p.**

A cooperative study was initiated to determine the feasibility of burning cholla after it has been cabled.

406. **U.S. Department of Agriculture. (No date). Santa Rita Experimental Range: Deferred grazing on mesquite-free and mesquite-infested range. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 2 p.**

Grazing capacities on mesquite-infested pastures and on mesquite-free pastures increased 62% and 170% in 7 years, respectively, as a result of alternate-year deferment of grazing.

407. **U.S. Department of Agriculture. (No date). Santa Rita Experimental Range: Establishment of buffalograss in intermediate pits. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 2 p.**

Initial establishment of buffalograss was somewhat better in the conventional pits than in the intermediate pits. However, production on conventional pits generally declined after the second year, whereas production continued to increase through the fourth year in the intermediate pits.

408. **U.S. Department of Agriculture. (No date). Santa Rita Experimental Range: Factors affecting veg-**

etation change. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 2 p.

Year to year changes in rainfall influenced short-term changes in vegetation more than any single factor. Mesquite removal increased perennial grass production by 42% and annual grass production by 42%. Distances up to 1 mile from water did not greatly reduce utilization by cattle.

409. U.S. Department of Agriculture. (No date). Santa Rita Experimental Range: Forage quality study. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 2 p.

Browse species averaged about 2.5 times more crude protein than grasses. Cacti and forbs together have almost twice as much crude protein as perennial grasses.

410. U.S. Department of Agriculture. (No date). Santa Rita Experimental Range: Improving distribution of grazing use with salt and salt meal. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 1 p.

Early results show that the pattern of utilization within the range unit can be improved somewhat by placing salt or salt meal in areas where past use has been light.

411. U.S. Department of Agriculture. (No date). Santa Rita Experimental Range: Long-time changes in mesquite. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 1 p.

Dramatic changes in the character and distribution of mesquite stands over a span of years have been recorded on SRER by means of repeat photographs.

412. U.S. Department of Agriculture. (No date). Santa Rita Experimental Range: Mesquite thinning studies. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 2 p.

Mesquite removal greatly increased perennial grass production where annual rainfall is 14 inches or more. Response is less predictable where annual rainfall is 13 inches or less.

413. U.S. Department of Agriculture. (No date). Santa Rita Experimental Range: Moisture use by burroweed and grass. Fort Collins, CO: U.S. Department of Agriculture, ForestService, Rocky Mountain Forest and Range Experiment Station. 2 p.

Competition for soil moisture depended primarily on the character of the root system and the season of active growth for each species.

414. U.S. Department of Agriculture. (No date). Santa Rita Experimental Range: Results of burning trials. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 2 p.

A burning study showed that a June fire will kill about 90% of the burroweed, up to 40-50% of the cholla and prickly pear cactus, but only a few mesquite.

415. U.S. Department of Agriculture. (No date). Santa Rita Experimental Range: Rotating use of waters. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 1 p.

The perennial grass cover around some of the rotated watering places has increased and remained consistently higher than around the yearlong water.

416. U.S. Department of Agriculture. (No date). Santa Rita Experimental Range: Santa Rita validation site - Desert Biome Program, IBP. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 2 p.

The proposed research program on the validation site is described.

417. U.S. Department of Agriculture. (No date). Santa Rita Experimental Range: Season of grazing study. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 2 p.

Public information note describing a study designed to determine changes in vegetation resulting from grazing in the different seasons.

418. U.S. Department of Agriculture. (No date). Santa Rita Experimental Range: Seasonal deferment study. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 2 p.

Public information note describing the objectives of the proposed study which were to determine which of several combinations of rest periods when the range is ungrazed leads to the greatest improvement in perennial grass vegetation.

419. U.S. Department of Agriculture. (No date). Santa Rita Experimental Range: Vegetation-soil associations. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 1 p.

Some vegetation differences on SRER are due to generic soil properties.

420. Van Devender, Thomas Roger. 1973. Late pleistocene plants and animals of the Sonoran Desert: A survey of ancient packrat middens in southwestern Arizona. Tucson, AZ: Department of Geosciences, University of Arizona. 179 p. Ph.D. dissertation.

Some 24 radiocarbon age determinations yielded dates on 14 Pleistocene-age middens from more than 30,000 to about 11,000 years ago. These middens contained fossils of 90 species of plants and 42 species of animals. From 25% to 35% of the plant fossils are extra local woodland species. The climatic change that marked the onset of the post-glacial and the last major change in biotic communities in the Sonoran Desert was about 11,000 years ago. Other data suggest that the Ice Age conditions affected the climate and biotic communities of southwestern Arizona only minimally.

421. Vaughan, Pamela Jane. 1972. Dispersal in a small mammal population. Tucson, AZ: University of Arizona. 61 p. M.S. thesis.

Dipodomys merriami and *Perognathus penicillatus* had relatively small dispersal distances, while *Onychomys torridus* moved large distances. Most shifts in home range were made by adults. A significant correlation existed between the mean distance between successive recaptures and the average maximum distance between all points of capture. Little difference was found in numbers or movements of individuals on disturbed and undisturbed areas.

422. Vaughn, Thomas Charles. 1976. Effects of woody vegetation removal on rodent populations at Santa Rita Experimental Range, Arizona. Tucson, AZ: Department of Ecology and Evolutionary Biology, University of Arizona. 106 p. Ph.D. dissertation.

The initial impact of chaining resulted in overall decrease in rodent populations, especially *Dipodomys merriami*. Home range sizes were not significantly altered for any species as a result of vegetation removal. *Perognathus flavus* became more common on chained areas.

423. Vorhies, Charles T. 1928. Do southwestern quail require water? The American Naturalist. 62(682): 446-452.

Water is not the limiting factor affecting quail numbers. The chief factor delimiting populations is legal and illegal hunting.

424. Vorhies, Charles T. 1932. First record of the pectoral sandpiper for Arizona. Condor. 34: 46-47.

Two male pectoral sandpipers (*pisobia melanotos*) were observed and collected on SRER in September 1931.

425. Vorhies, Charles T. 1945. Water requirements of desert animals in the Southwest. Technical Bulletin 107. Tucson, AZ: University of Arizona, Agricultural Experiment Station: 487-525.

Food habits of four species were correlated with its habitat and microclimate. Kangaroo rats conserve water via physiology and deep burrowing nocturnal habits. Wood rats do not drink but make use of more succulent foods. The round-tailed ground squirrel uses much succulent food and drinks water when available. Jackrabbits drink water only under most unusual circumstances and use highly succulent foods, mainly mesquite and cactus.

426. Vorhies, Charles T.; Taylor, Walter P. 1922. Life history of the kangaroo rat, Dipodomys spectabilis spectabilis Merriam. Bulletin 1091. Washington, DC: U.S. Department of Agriculture. 40 p.

This comprehensive study deals with the general habits, foods, breeding, habitats, economic status, and impacts on rangelands.

427. Vorhies, Charles T.; Taylor, Walter P. 1924. Damage by kangaroo rats. Journal of Mammology. 5(2): 144.

Corrections in data and interpretation of the authors' previous paper, "Life history of the kangaroo rat" (U.S. Department of Agriculture Bulletin 1091 [1922]), are presented.

428. Vorhies, Charles T.; Taylor, Walter P. 1933. The life histories and ecology of jackrabbits, Lepus alleni and Lepus californicus spp., in relation to grazing in Arizona. Technical Bulletin 49. Tucson, AZ: University of Arizona, Agricultural Experiment Station. 117 p.

This comprehensive study presents information on behavioral habits, breeding, foods, habitats, distribution, energetics, diseases and parasites, population estimation methods, and economic status. Differences between L. alleni and L. californicus are highlighted.

429. Vorhies, Charles T.; Taylor, Walter P. 1940. Life history and ecology of the white-throated wood rat, Neotoma albigula albigula Hartley, in relation to grazing in Arizona. Technical Bulletin 86. Tucson, AZ: University of Arizona, Agricultural Experiment Station. 75 p.

This study presents extensive information related to general description and habits, breeding, foods and food habits, habitat requirements, mortality factors, and economic status of the white-throated wood rat.

430. Voth, Arnold. 1938. Summary of investigations dealing with burroweed (Aplopappus fruticosus) and its ecological aspects. Tucson, AZ: University of Arizona. 76 p. M.S. thesis.

The biogeography of burroweed is discussed and specific site conditions are given. Additional notes are provided on economic status, phenology, germination and reproduction, water requirements, roots, abundance, and control methods.

431. Wallace, D. E.; Lane, L. J. 1976. Geomorphic thresholds and their influence on surface runoff from small semiarid watersheds. Proceedings of

the 1976 Joint Annual Meeting of the Hydrology and Water Resources in Arizona and the Southwest, American Water Resources Association, Arizona Section--Arizona Academy of Science, Hydrology Section; 169-176.

The geomorphic threshold concept of landform evolution and its effect on hydrologic performance of drainage systems was investigated on small semiarid watersheds in southeastern Arizona. Thresholds develop within a geomorphic system with time and can, when exceeded, cause drastic changes in the geomorphic features and in the hydrologic performance of the watershed. The slow continuous evolution of drainage characteristics can be suddenly altered with major readjustment of the landscape taking place. A new state of dynamic equilibrium will then prevail until the drainage system is again subjected to conditions that cause some geomorphic threshold to be exceeded. Areas of potential geomorphic readjustment can be identified from parameters such as channel slope, average land surface slope, drainage density, and mean length of first order streams and these data can be used as components in a calibrated kinematic-cascade model to determine the effects of various degrees of drainage system alteration. The influence on runoff from exceeding various geomorphic thresholds is tested and the resulting hydrologic modifications are simulated and discussed.

432. Wallace, D. E.; Lane, L. J. 1978. Geomorphic features affecting transmission loss potential on semiarid watersheds. Proceedings of the 1978 Joint Annual Meeting of the Hydrology and Water Resources in Arizona and the Southwest, American Water Resources Association, ArizonaSection--Arizona Academy of Science, Hydrology Section; 8:157-164.

Water yield studies and flood control surveys often necessitate estimating transmission losses from ungaged watersheds. There is an immediate need for an economical method that provides the required accuracy. Analysis of relations between stream order, drainage area, and volume of channel alluvium existing in the various orders is one means of estimating loss potential. Data needed for the stream order survey are taken from aerial photos. Stream order is analyzed using stereophoto maps. Stream lengths taken from the maps are combined with average channel width and depth data (determined by prior surveys) to estimate volumes of alluvium involved. The volume of channel alluvium in a drainage network is directly related to the stream order number of its channels. Thus, a volume of alluvium within a drainage network (with a known transmission loss potential) may be estimated by knowing the order of each length of channel and the drainage areas involved. In analyzing drainage areas of 56-mi^2 or less, 70-75% of the total drainage network length is contained within first and second order channels; yet, these constitute less than 10% of the total transmission loss potential of the areas. Analysis of stream order and drainage area versus volume of alluvium relations allows preliminary estimates of transmission loss potential to be made for ungaged areas.

433. Warburg, Michael R. 1965. The microclimate in the habitats of two isopod species in southern Arizona. American Midland Naturalist. 73(2): 363-375.

The paper describes the microclimate in a mesic habitat of Armadillidium vulgare, and a xeric habitat of Venezillo arizonicus, two isopods found in southern Arizona. Within a small area, a significant divergence in microclimatic conditions was found. The climate under cover was in general less extreme than the climate in exposed places. Thus, the microclimate under a stone was least variable. The main difference in microclimate of different sites within the habitat was in relative humidity. In general the temperature in the xeric habitat was higher than in the mesic habitat. Conditions on the ground in the mesic habitat permitted an isopod to move about without danger of desiccation; this was not possible in the xeric habitat.

434. Ward, Donald E. 1975. Seasonal weight changes of cattle on semidesert grass-shrub ranges. Journal of Range Management. 28(2): 97-99.

Average cow weights on semidesert grass-shrub ranges of SRER in southern Arizona increased slightly following spring green-up, but major weight gains began with summer forage and continued into November. Major weight losses were at calving time in December and January.

435. Ward, Donald E.; Martin, S. Clark. 1972. Tanglehead--a dual purpose grass. Arizona Cattlelog. 28(8): 18-20.

The positive and negative aspects of Heteropogon contortus are discussed. It is most valuable as emergency forage and as a gully healer.

436. Werner, F. G. 1973. Foraging activity of the leaf-cutter ant, Acromyrmex versicolor, in relation to season, weather and colony condition. US/IBP Desert Biome Research Memorandum 73-28. Logan, UT: Ecology Center, Utah State University. 13 p.

This report covers the foraging of 33 marked colonies of Acromyrmex versicolor on a 0.36 ha study plot on the Santa Rita Validation Site in 1971. An analysis of the data indicates that peak foraging activity reached well over 300,000 trips per 24-hr day during the most active period on this plot and would run over a million per ha. Plants and parts selected changed through the season, with some that were especially favored gradually being removed entirely. Because of the heavy concentration of foraging in the rainy monsoon period, plants selected then probably are utilized much more heavily than those favored at other seasons.

437. **Werner, F. G.; Murray, Steven L. 1972. Demography, foraging activity of leaf-cutter ants, Acromyrmex versicolor, in relation to colony size and location, season, vegetation and temperature. US/IBP Desert Biome 1971 Progress Report. Logan, UT: Ecology Center, Utah State University. 10 p.**

The workers foraged in columns along trail routes and used different trails to different forage sources through the monitored seasons. Foraging period was nocturnal in the summer, crepuscular in spring and fall, and diurnal in winter. Initiation and cessation of daily foraging was influenced by nest location; summer rainfall induced maximum foraging. Prosopis juliflora was the most abundant forage source, and P. juliflora leaflets were the most often taken forage material. When prostrate annuals Allionia incarnata and Euphorbia melandenia were foraged, the entire plant was sectioned and removed. The flower parts of all plants taken were favored over vegetative material.

438. **Werner, Floyd G.; Butler, George D., Jr. (No date). A survey of the insects on mesquite in southern Arizona. Unpublished report. Tucson, AZ: Department of Entomology, University of Arizona. 9 p. [Available at U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, Tempe, Arizona.]**

A study was initiated to determine the insect populations present on stands of mesquite. Obvious damage to trees by insects was identified by species.

439. **Westerman, R. L. 1974. Organic constituents in soils. US/IBP Desert Biome Research Memorandum 74-48. Logan, UT: Ecology Center, Utah State University. 3 p.**

Estimates of undecomposed organic material on top of Sonoita sandy loam soils on SRER are reported. Three times more litter was present under mesquite canopies than on soils covered with grass. In soils covered with grass and mesquite, humic acid decreased with depth. Nitrogen concentration in the humic acid fraction was highest in the surface and tended to decrease with depth.

440. **White, Larry D. 1968. Factors affecting susceptibility of creosotebush (Larrea tridentata (D.C.) Cov.) to burning. Tucson, AZ: Department of Watershed Management, University of Arizona. 96 p. Ph.D. dissertation.**

Results indicate a seasonal relationship in mortality of creosotebush following burning. Mortality was attributed to high fire intensities and poor growing conditions. Morphological characteristics related to plant age influenced sprout production following burning.

441. **Williams, Patrick Thomas. 1976. Grass production changes with mesquite (Prosopis juliflora) reinvasion in southern Arizona. Tucson, AZ: University of Arizona. 37 p. M.S. thesis.**

Grass yields on complete mesquite control were greater than on untreated plots. Grass yields were negatively related to thinning density. Retreatment following mesquite control is not needed for at least 30 years if all the mesquites are killed initially.

442. **Wilson, David George. 1961. Characteristics of a southern Arizona desert grassland soil related to mesquiteinvasion. College Station, TX: School of Agricultural and Mechanical College of Texas, Texas A&M University. 94 p. Ph.D. dissertation.**

Comparison of species composition of mesquite-invaded and uninvaded areas showed a significant difference in vegetation of the two areas. Total shrub cover averaged between 10.4% and 12.6% on uninvaded areas, and between 22.1% and 25.2% on invaded areas. Mesquite constituted about 65% of the woody cover on the invaded areas; calliandra was the major component on the uninvaded areas. Velvet pod mimosa was present in lesser amounts on both invaded and uninvaded areas. Invaded areas tended to have lower clay content and a higher sand content. None of the chemical characters evaluated showed a significant relationship to mesquite invasion.

443. **Winter, C. Larrabee. 1976. Relationships among climate, tree-ring widths and grass production on the Santa Rita Experimental Range. Tucson, AZ: University of Arizona. 121 p. M.S. thesis.**

Except in summer, precipitation and temperature variation within the region are correlated over both distance and elevation. Grass production responded to some of the same climatic variables as total and early wood width chronologies. Early wood and total ring-width chronologies are significantly correlated with grass production.

444. **Wondolleck, John T. 1978. Forage-area separation and overlap in heteromyid rodents. Journal of Mammalogy. 59(3): 510-518.**

Forage-area separation and overlap of four species of seed-eating desert rodents were measured by placing seed dyed four colors in four microhabitats and allowing the rodents to forage and ingest the seed. The four microhabitats were delineated as follows: (1) areas lacking vegetation; (2) areas containing small scattered bushes; (3) areas containing clumped bushes; and (4) areas containing large bushes. Dipodomys merriami foraged in areas lacking vegetation, Perognathus amplus among scattered and clumped vegetation, P. baileyi among clumped vegetation and large bushes, and P. penicillatus under large bushes. Dipodomys affected habitat selected by P. amplus. Perognathus baileyi preferred gravelly soils and may exclude D. merriami from this substrate. Habitat selection was found to be an important factor in the coexistence of these species.

445. **Wondolleck, John Thomas. 1975. The influence of interspecific interactions on the forage areas of Heteromyidrodents. Tucson, AZ: University of Arizona. 35 p. M.S. thesis.**

Dipodomys merriami foraged in areas lacking vegetation, Perognathus amplus foraged among scattered and clumped vegetation, and Perognathus baileyi foraged among clumped vegetation and large bushes. Dipodomys affected the habitat selected by P. amplus. Perognathus baileyi and P. penicillatus did not change their forage patterns. Habitat selection was found to be important for the coexistence of these species, with interspecific interactions partially influencing habitat selection.

446. **Wooten, E. O. 1916. Carrying capacity of grazing ranges in southern Arizona. Bulletin 367. Washington, DC: U.S. Department of Agriculture. 40 p.**

The carrying capacity of completely protected areas improved considerably over used areas. Three years of complete protection gave about three-fourths of complete recovery for an area where crowfoot grama is the dominant grass, at levels of 3,500 to 4,000 mean sea level with 15-18 inches of annual rainfall. Other areas stocked to capacity showed better productivity than adjacent unprotected pastures of the same character. Most reseeding attempts have resulted in negative results with possible exception of a few native species. Stocking rates for SRER are suggested. Miscellaneous notes on effects of fire, effects of protection on the minor relief features of the area, reseeding, and sheep grazing are presented.

447. **Yavitt, Joseph Benjamin. 1979. Quadrat frequency sampling in a semi-desert grassland. Tucson, AZ: School of Renewable Natural Resources, University of Arizona. 67 p. M.S. thesis.**

A 10 m^2 plot was needed to record 50% of total species present in a stand. Species frequency was recorded in .16 m^2 quadrats in a 20 x 20 grid spaced at 1.25 m intervals. Occurrence of species was found to be independently distributed. Use of transects gave no increase in precision compared to grid placement. A comparison of sampling efficiency of rectangular plots to linear plots resulted in a sample number of 9-10 plots in both cases.

448. **Yeager, Mike; Martin, S. Clark. 1965. Results of 1964 deer hunt on the Santa Rita Experimental Range. Tempe, AZ: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, and Arizona Game and Fish Department. 18 p. [Mimeo.]**

Permits were issued for 100 antlered and 100 antlerless deer. Fifty-four deer were killed by 167 hunters. Average winter success was 32.3% compared to 20.1% for outside SRER. Desert mule deer accounted for 65% of the kill; the remainder were whitetail. Two-thirds of the deer that were killed were antlerless and 22% were fawns. The data suggest that there was a build-up of desert mule deer females on the protected wildlife area, but there was no evidence of a similar build-up in whitetail of either sex or in desert mule deer bucks.

449. **Youngs, F. O.; Poulson, E. N. 1931. Soil survey of the Santa Rita Experimental Range, Arizona. Washington, DC: U.S. Department of Agriculture, Bureau of Chemistry and Soils. 56 p.**

The soils of SRER are described and classified.

450. **Youngs, F. O.; Sweet, A. T.; Strahorn, A. T.; Glassey, T. W.; Poulson, E. N. 1936. Soil survey of the Tucson Area, Arizona. Washington, DC: U.S. Department of Agriculture, Bureau of Chemistry and Soils. 60 p.**

The soils of SRER and adjacent agricultural areas are described.

451. **Zemo, Tesfay. 1968. Behavior and grazing preference of fistulated steers on a desert grassland. Tucson, AZ: University of Arizona. 61 p. M.S. thesis.**

Steers followed a systematic behavioral pattern: they grazed for 6.7 hours, ruminated for 4.4 hours, stood idle for 1.2 hours, and lay idle for 1 hour. During the night steers grazed 2 hours, ruminated 2.4 hours, stood idle for 0.25 hour and lay idle for 3.7 hours. Steer preference for plant species in priority order was Arizona cottontop, slender grama, plains bristlegrass, sideoats grama, forbs, Santa Rita threeawn, shrubs, bush muhly, and black grama.

452. **Zemo, Tesfay; Klemmedson, James O. 1970. Behavior of fistulated steers on a desert grassland. Journal of Range Management. 23(2): 158-163.**

Steers consistently grazed during four definite daylight grazing periods and two nighttime periods throughout the study. The four steers were remarkably similar in their activities and differed only in salting time; their activities did not appear to differ from those of intact cattle. Activities were similar on mesquite and mesquite-free pastures. As the grazing season advanced and forage matured, rumination time increased and frequency of urination declined.

APPENDICIES FOLLOW

Appendix A. Soils on the Santa Rita Experimental Range[1]

Order	Subgroup	Soil series	Acres	Percent of area	Slope (%)	Erodibility	Erosion hazard
Entisol	Typic Torri fluvent	Anthony	9,674	18.2	0 - 5	Mod.	Low
"	" "	Anthony, very grav. variant	783	1.5	0 - 5	Mod.	Low
Aridisol	Typic Haplargid	Sonoita, grav. sandy loam	10,425	19.6	1 - 8	Mod.	Low
Aridisol	Typic Haplargid	Sonoita, grav. sandy loam	133	0.2	8 - 20	Mod	Mod.
Aridisol	Typic Haplargid	Continental	2,780	5.2	1 - 10	High	Low
Aridisol	Typic Haplargid	Eba	2,609	5.0	0 - 10	Low	Low
Aridisol	Typic Haplargid	Pinaleno	587	1.1	0 - 10	Mod.	Low
Aridisol	Ustollic Haplargid	White House, grav. sandy, loam	1,098	2.0	0 - 10	High	Low
Aridsol	" "	White House	2,413	4.5	1 - 15	Mod.	Mod.
"	" "	White House-Caralampi	1,143	2.1	10 - 35	Mod.	High
"	" "	Caralampi	962	1.8	10 - 40	High	Mod.
"	" "	Bernardino	1,460	2.8	2 - 30	Mod.	Mod.
"	" "	Chiricahua, Lampshire	311	0.6	8 - 25	High	Mod.
"	Typic Paleorthid	Cave	799	1.6	0 - 5	Mod.	Low
Mollisol	Cumulic Haplustoll	Comoro	9,015	16.9	0 - 5	Mod.	High
"	" "	Comoro, sandy, loam	1,192	2.2	0 - 10	High	High
"	Lithic Haplustoll	Mabray, Chiricahua Complex	1,995	3.8	8 - 45	Mod.	High
"	" "	Lampshire, Chiricauhua	2,109	4.1	15 - 50	High	High
"	Fluventic "	Pima	918	1.7	0 - 5	High	High
"	Calciustoll	Hathaway	974	1.8	2 - 30	Mod.	Mod.
"	"	Rock Land	97	0.2	15 - 45	High	High
"	"	Gravelly alluvial land	1,682	3.1	0 - 5	High	High
			53,159	100			

[1] *Adapted from Clemmons and Wheeler (1970).*

Appendix B. Vertebrates on the Santa Rita Experimental Range

Scientific name	Common name
Mammals	
Ammospermophilus harrisii	Harris's antelope squirrel
Bassariscus astutus (Lichtenstein)	Ringtail
Canis latrans Say	Coyote
Citellus harrisi (Audubon and Bachman)	Gray-tailed antelope squirrel
Citellus tereticaudus (Baird)	Round-tailed ground squirrel
Conepatus mesoleucus (Lichtenstein)	Western rooter skunk
Dipodomys merriami (Mearns)	Merriam kangaroo rat
Dipodomys spectabilis (Merriam)	Bannertail kangaroo rat
Lepus alleni (Mearns)	Antelope jackrabbit
Lepus californicus (Gray)	Black-tailed jackrabbit
Lynx rufus (Schreber)	Bobcat
Mephitis mephitis (Schreber)	Common striped skunk
Mus musculus	House mouse
Mammals (Cont'd)	
Neotoma albigula (Hartley)	White-throated packrat
Odocoileus hemionus (Rafinesque)	Mule deer
Odocoileus virginianus (Zimmerman)	White-tailed deer
Onychomys leucogaster (Maximilian)	Grasshopper mouse
Onychomys torridus	Scorpion mouse
Perognathus amplus (Osgood)	Arizona pocket mouse
Perognathus baileyi (Merriam)	Bailey pocket mouse
Perognathus flavus	Silky pocket mouse
Perognathus penicillatus	Desert pocket mouse
Peromyscus eremicus	Cactus mouse
Peromyscus leucopus	Wood mouse
Peromyscus maniculatus	Deer mouse
Peromyscus merriami Mearns	Merriam mouse
Reithrodontomys fulvescens	Fulvous harvest mouse
Reithrodontomys megalotis (Baird)	Desert harvest mouse

(Cont'd.)

Scientific name	Common name
Mammals (Cont'd)	
Reithrodontomys montanus	Plains harvest mouse
Sigmodon arizonae	Arizona cotton rat
Spermophilus tereticaudus	Round-tailed ground squirrel
Sylvilagus auduboni	Desert cottontail
Taxidea taxus (Schreber)	Badger
Tayassu tajacu (Linnaeus)	Collared peccary
Urocyon cinereoargenteus (Schreber)	Gray fox
Birds	
Aimophila botterii (Schlater)	Botteri's sparrow
Aimophila carpalis (Coues)	Rufous-winged sparrow
Aimophila cassinii (Woodhouse)	Cassin's sparrow
Aimophila ruficeps (Cassin)	Rufous-crowned sparrow
Ammodramus savannarum (Gmelin)	Grasshopper sparrow
Amphispiza bilineata (Cassin)	Black-throated sparrow
Archilochys alexandri (Bourcier and Mulsant)	Black-chinned hummingbird
Auriparus flaviceps (Sundevall)	Verdin
Bubo virginianus (Gmelin)	Great horned owl
Buteo jamaicensis (Gmelin)	Red-tailed hawk
Calamospiza melandcorys (Stejneger)	Lark bunting
Callipepla squamata (Vigors)	Scaled quail
Calypte costae (Bourcier)	Costa's hummingbird
Campylorhynchus brunneicapillum (Lafresnaye)	Cactus wren
Carpodacus mexicanus (Muller)	House finch
Cathartes aura (Linnaeus)	Turkey vulture
Chordeiles acutipennis (Hermann)	Lesser nighthawk
Corvus corax (Linnaeus)	Common raven
Dendrocopus scalaris (Wagler)	Ladder-backed woodpecker
Dendroica auduboni (Townsend)	Audubon's warbler
Geococcyx californianus (Lesson)	Roadrunner
Guiraca caerulea (Linnaeus)	Blue grosbeak
Icterus parisorum (Bonaparte)	Scott's oriole
Lanius ludovicianus (Linnaeus)	Loggerhead shrike
Lophortyx gambelii (Gambel)	Gambel's quail
Birds (Cont'd)	
Mimus polyglottos (Linnaeus)	Northern mockingbird
Myiarchus cinerascens (Lawrence)	Ash-throated flycatcher
Phainopepla nitens (Swainson)	Phainopepla
Pipilo fuscus (Swainson)	Brown towhee
Polioptila melanura (Lawrence)	Black-tailed gnatcatcher
Pyrocephalus rubinus (Boddaert)	Vermilion flycatcher
Pyrrhuloxia cardinalis (Linnaeus)	Cardinal
Pyrrhuloxia sinuata (Bonaparte)	Pyrrhuloxia
Salpinctes obsoletus (Say.)	Rock wren
Sayornis nigricans (Swainson)	Black Phoebe
Sayornis sayus (Bonaparte)	Say's Phoebe
Sturnella neglecta (Audubon)	Western meadowlark
Toxostoma bendirei (Coues)	Bendire's thrasher
Toxostoma curvirostre (Swainson)	Curve-billed thrasher
Toxostoma dorsale (Henry)	Crissal thrasher
Tyrannus verticalis (Say)	Western kingbird
Vermivora luctae (Cooper)	Lucy's warbler
Vireo bellii (Audubon)	Bell's vireo
Zenaida asiatica (Linnaeus)	White-winged dove
Zenaida macroura (Linnaeus)	Mourning dove
Zonotrichia leucophrys (Forster)	White-crowned sparrow
Reptiles and Amphibians	
Cnemidophorus sacki (Wiegmann)	Spotted whiptail
Crotalus molossus (Baird and Girard)	Black-tailed rattlesnake
Crotalus viridis (Rafinesque)	Western rattlesnake
Heloderma suspectrum (Cope)	Gila monster
Masticophis bilineatus (Jan)	Sonora whipsnake
Masticophis taeniatus (Hallowell)	Striped whipsnake
Phrynosoma douglassi (Bell)	Short-horned lizard
Pituophis catenifer (Blainville)	Gopher snake
Sceloporus clarki (Baird and Girard)	Clark's spiny lizard
Sceloporus undulatus (Bosc. in Latreille)	Eastern fence lizard

Appendix C. Plants on the Santa Rita Experimental Range

Scientific name	Common name
Acacia angustissima(Mill.)Kuntze	Whiteball acacia
Acacia greggii A. Gray	Catclaw acacia
Agave palmeri Engelm.	Palmer agave
Allionia incarnata L.	Trailing allionia
Amaranthus sp. L.	Amaranth
Andropogon barbinodis Lag.	Cane blue-stem
Arctostaphylos pungens H.B.K.	Pointleaf manzanita
Aristida adscensionis	Sixweeks threeawn
Aristida hamulosa	Desert threeawn
Aristida glabrata	Santa Rita threeawn
Aristida ternipes	Spidergrass
Aristolochia watsonii	Watson dutchmanspipe
Atriplex canescens	Fourwing saltbush
Ayenia pusilla	Dwarf ayenia
Baccharis brachyphylla	Shortleaf baccharis
Boerhaavia coccinea	Scarlet spiderling
Boerhaavia torreyana	Torrey spiderling
Bouteloua aristidoides	Needle grama
Bouteloua chondrosioides	Sprucetop grama
Bouteloua curtipendula	Sideoats grama
Bouteloua eriopoda	Black grama
Bouteloua filiformis	Slender grama
Bouteloua hirsuta	Hairy grama
Bouteloua rothrockii	Rothrock grama
Calliandra eriophylla	Falsemesquite
Carnegiea gigantea	Saguaro
Cassia leptadenia	Senna
Celtis pallida	Desert hackberry
Cercidium microphyllum	Yellow paloverde
Chenopodium album	Lambsquarters goosefoot
Chloris virgata	Feather fingergrass
Cottea pappophoroides	Cotta grass
Cucurbita digitata	Gourd
Cucurbita foetidissima	Buffalo-gourd
Dasylirion wheeleri	Wheeler sotol
Daucus pusillus	Southwestern carrot
Ditaxis neomexicana	Ditaxis
Enneapogon desvauxii	Spike pappusgrass
Ephedra trifurca	Longleaf ephedra
Eragrostis chloromelas	Boer lovegrass
Eragrostis intermedia	Plains lovegrass
Eragrostis lehmanniana	Lehmann lovegrass
Eragrostis superba	Wilman lovegrass
Eriochloa gracilis	Southwestern cupgrass
Eriogonum wrightii	Wright eriogonum
Erodium cicutarium	Alfileria
Eschscholtzia californica	California poppy
Euphorbia sp.	spurge
Evolvulus arizonicus	N.A.
Ferocactus wislizenii	Barrel cactus
Festuca octoflora	Sixweeks fescue
Fouquieria splendens	Ocotillo
Franseria dumosa	White bursage
Haplopappus laricifolius	Larchleaf goldenweed
Haplopappus tenuisectus	Burroweed
Heteropogon contortus	Tanglehead
Hilaria belangeri	Curlymesquite
Hymenothrix wislizenii	N.A.
Juniperus deppeana	Alligator juniper
Kallstroemia grandiflora	Arizona poppy
Krameria parvifolia	Littleleaf krameria
Larrea tridentata	Creosote bush
Leptochloa dubia	Green sprangletop
Leptoloma cognatum	Witchgrass
Lotus humistratus	Deer-vetch
Lupinus sp.	Lupine
Lycurus phleoides	Wolftail
Mammillaria microcarpa	Fishhook mammillaria
Mimosa biuncifera	Catclaw mimosa
Mimosa dysocarpa	Velvetpod mimosa
Muhlenbergia emersleyi	Bullgrass
Muhlengergia porteri	Bush muhly
Opuntia engelmannii	Engelmann pricklypear
Opuntia fulgida	Jumping cholla
Opuntia santa-rita	Santa Rita pricklypear
Opuntia spinosior	Cane cholla
Opuntia versicolor	Cholla
Panicum arizonicum	Arizona panicum
Panicum hirticaule	Roughstalk witchgrass
Pappophorum mucronulatum	Feather pappusgrass
Pectocarya recurvata	N.A.
Plantago insularis	Desert indianwheat
Prosopis juliflora	Velvet mesquite
Quercus arizonica	Arizona white oak
Quercus emoryi	Emory oak
Quercus hypoleucoides	Silverleaf oak
Setaria macrostachya	Plains bristlegrass
Sida procumbens	N.A.
Solanum elaeagnifolium	Silverleaf nightshade
Sorghum halepense	Johnsongrass
Sporobolus airoides	Alkali sacaton
Sporobolus contractus	Spike dropseed
Sporobolus cryptandrus	Sand dropseed
Talinum aurantiacum	Flame flower
Trianthema portulacastrum	Desert horsepurslane
Trichachne californica	Arizona cottontop
Tridens muticus	Slim tridens
Tridens pulchellus	Fluffgrass
Xanthocephalum sarothrae	Broom snakeweed
Yucca elata	Soaptree yucca
Zinnia pumila	Desert zinnia

Appendix D.

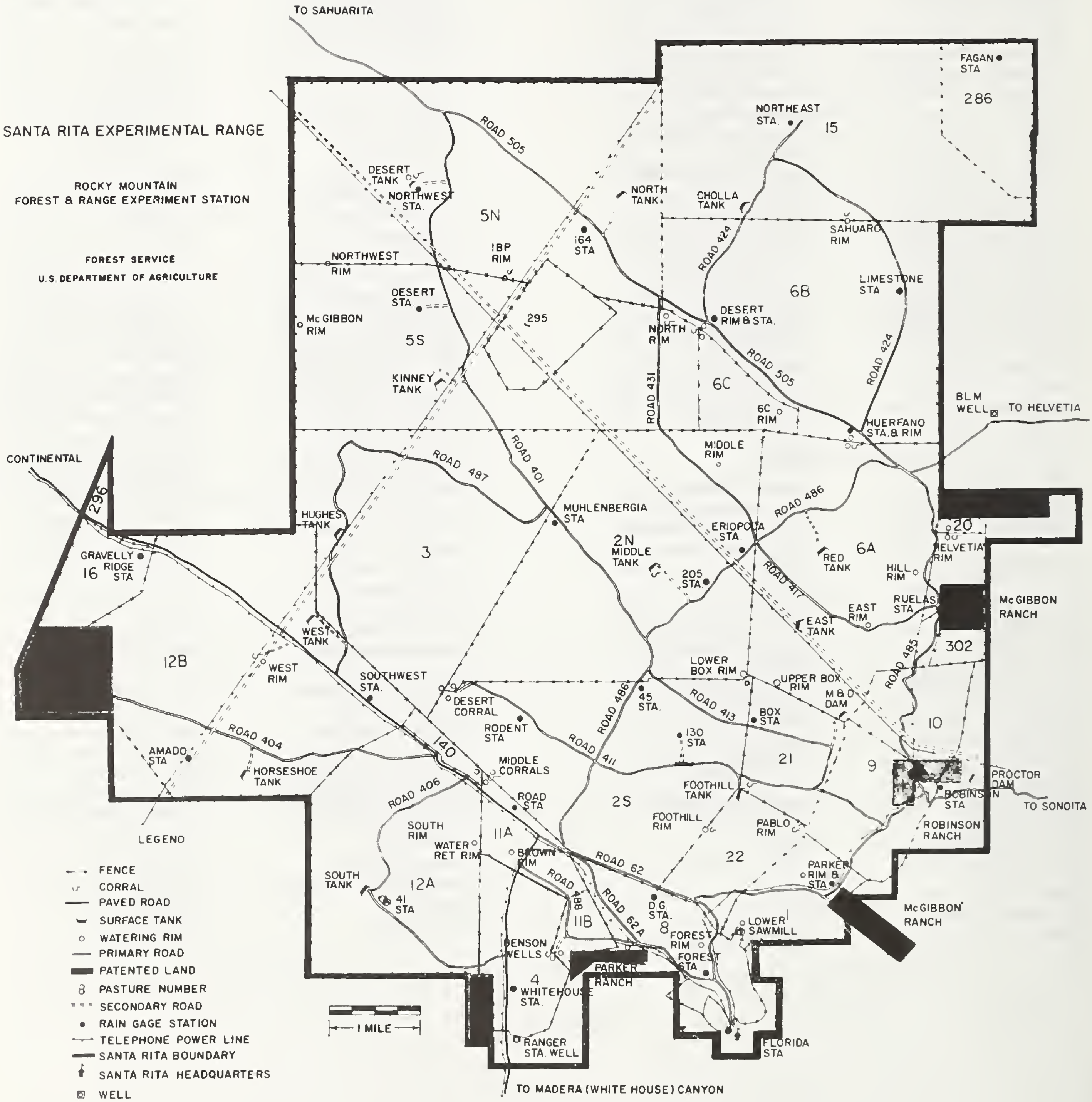

Figure 17. Map of the Santa Rita Experimental Range.

Appendix D. Cont'd.

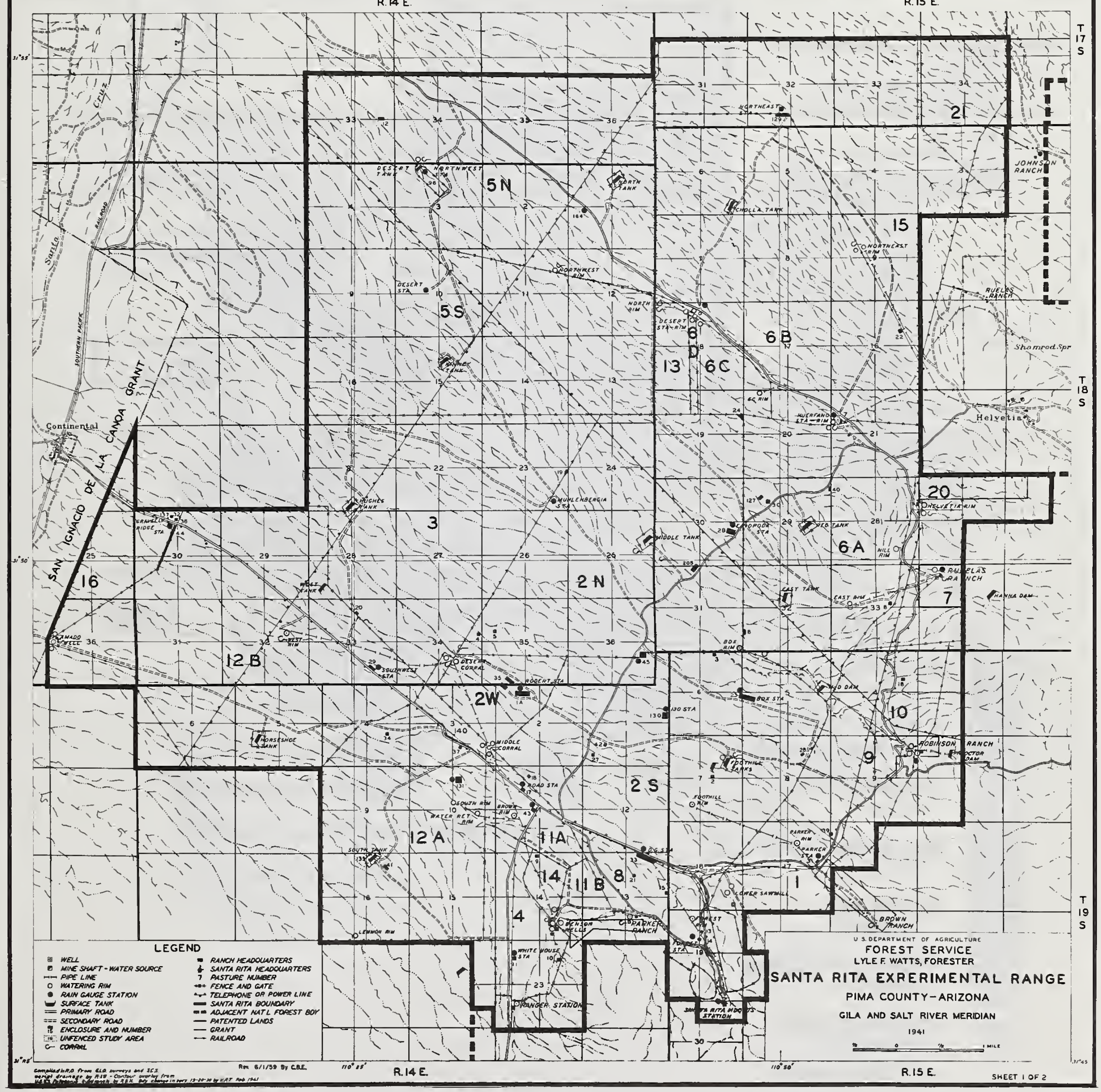

Figure 18. Physiographic map of SRER, 1941 edition.

Appendix D. Cont'd.

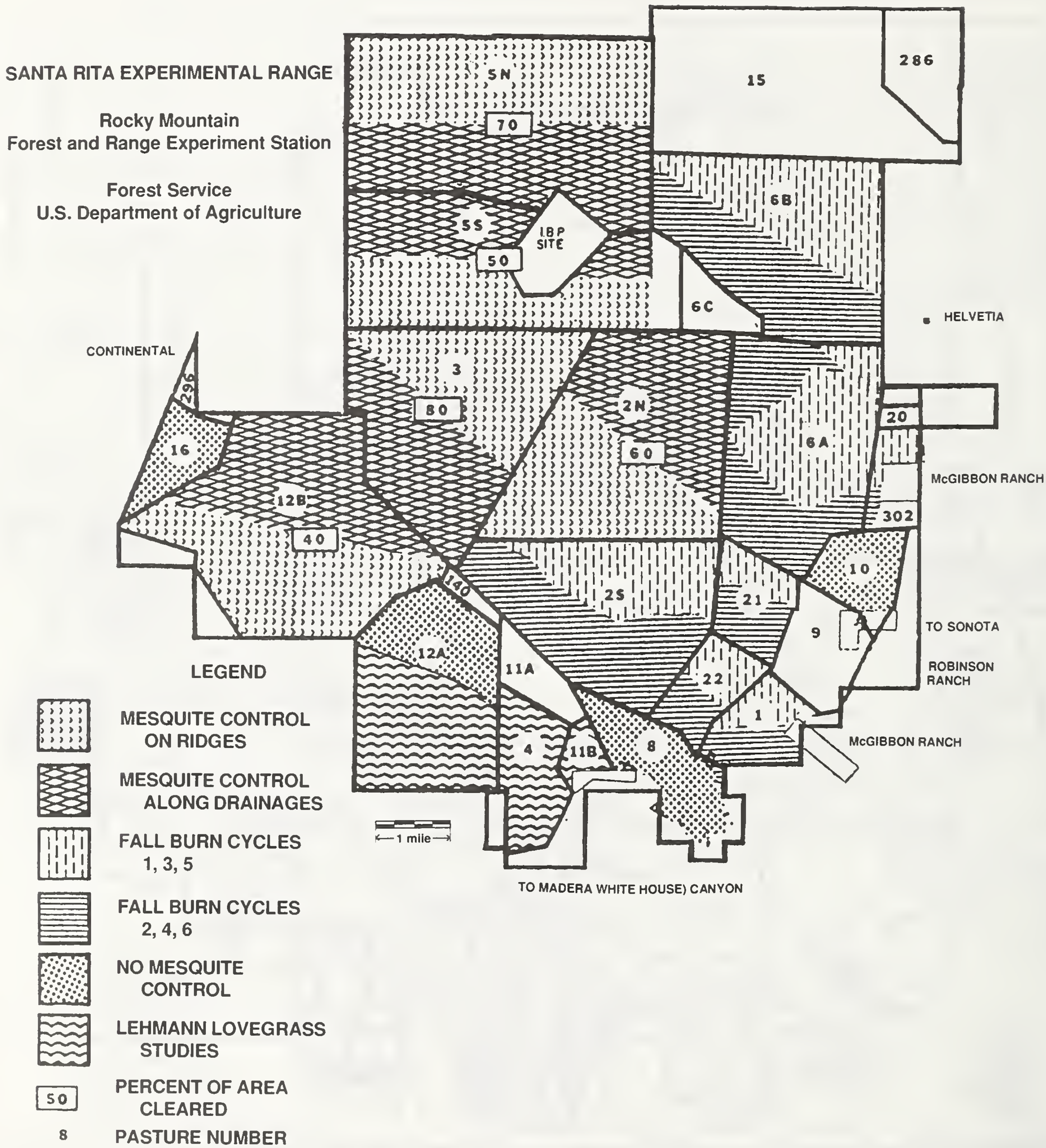

Figure 19. Map of SRER showing locations of various mesquite and Lehmann lovegrass studies, 1972 edition.

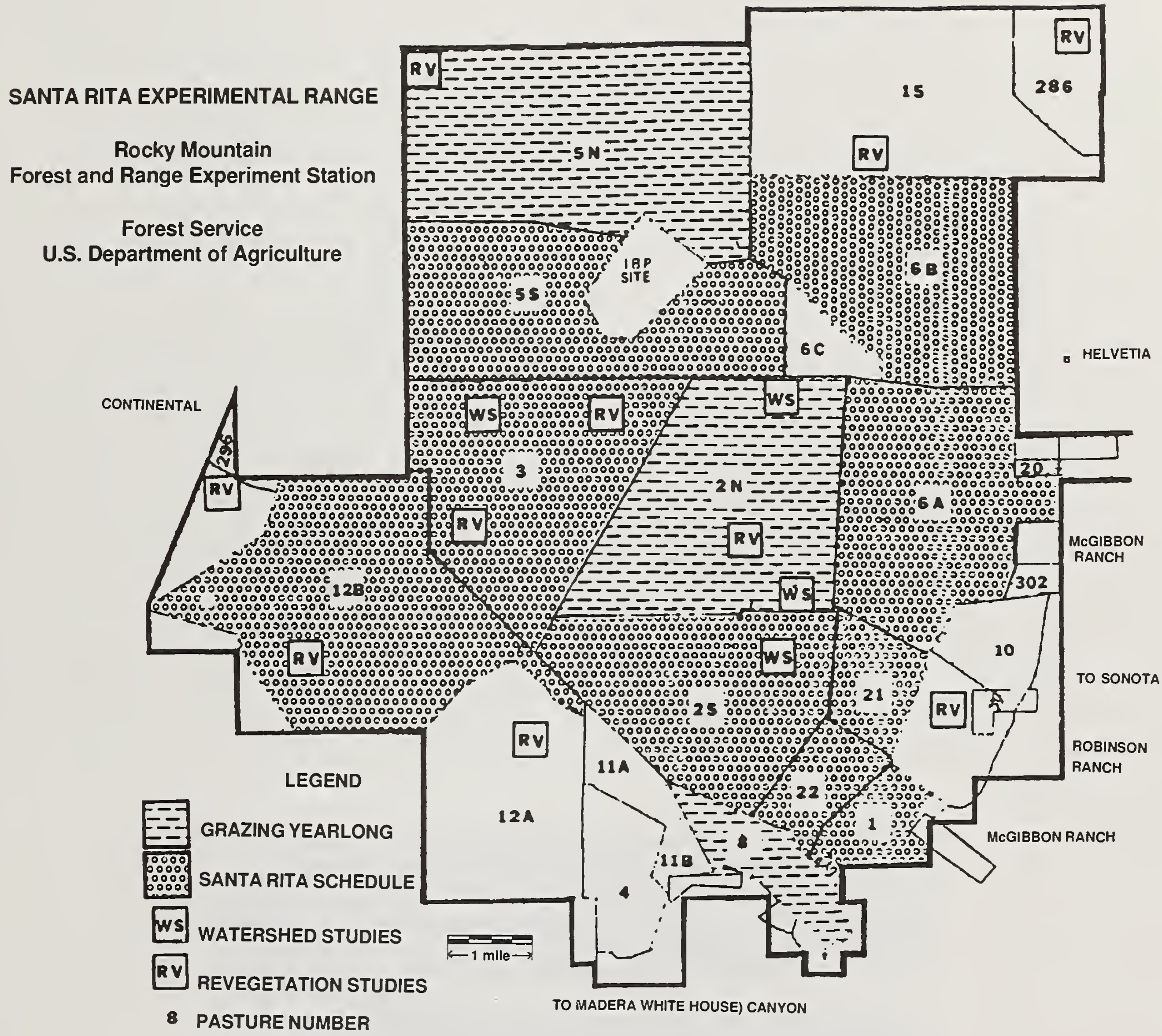

Figure 20. Map of SRER showing proportion of area allocated to grazing systems, watershed and revegetation studies, 1975 edition.

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